SECOND EDITION—In order to more quickly reprint the January, 1910, number the linotype machine was used, following line for line the regular hand-set edition. The extra spacing was made necessary that the Annual Index may apply to this edition as well as the first.—EDITOR.

Popular Astronomy.

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THE ROTATION OF VENUS AND LIFE ON PLANETS OTHER THAN THE EARTH.

T. J. J. SEE

FOR POPULAR ASTRONOMY.

In POPULAR ASTRONOMY for October, 1909, will be found a discussion by N. W. Mumford of the possibilities of the several planets as regards conditions which admit of the development of life. The trend of the argument there advanced is favorable to Venus rather than Mars, as the principal abode of life outside of our own planet, even if the day on Venus be of 225 days' duration, corresponding to a sidereal revolution around the Sun. But the force of the argument will be greatly strengthened if it turns out that the rotation of Venus is short, as now seems almost certain to be the case. The problem of the rotation of Venus is to-day a leading one in astronomy; and its permanent solution will be awaited with great interest not only by those who are interested in the habitability of the planets, but also by the mathematician who is occupied with the deeper problems of celestial mechanics. We propose therefore to give a brief outline of the situation as it stands to-day, and to point out a field in which an astronomer with a small telescope or an amateur may do most excellent work in the present favorable situation of Venus.

The question of the rotation of Venus presents great interest owing to two leading considerations:

(1) A rapid rotation of the planet on the axis which would give alternation of day and night, if not absolutely necessary for the development of life, would at least be highly favorable to the existence of animals and plants as known on the Earth; and if such rotation could be assured for Venus the outcome would go a long way towards establishing the habitability of the Earth's twin sister in space.

(2) The question of the secular effects exerted by tidal friction in retarding the Earth's rotation needs illumination from other sources; and of all the possible bodies to which we can appeal,

this inner planet, Venus, presents the most favorable conditions for a satisfactory answer. It is the only planet whose rotation period would be likely to prove absolutely decisive for or against tidal friction as an effective cause in modifying the rotations of the bodies such as we find in the solar system.

With these two weighty problems hanging in the balances, it is clear that Venus presents to us at present a far greater interest than any other planet. The study of it is ten times more important than Mars, on which we bestow so much attention; and not even the rare visit of Halley's comet is likely to give us permanent data to be compared with a really reliable determination of the rotation period of Venus.

It is the more remarkable that so little attention has been given to Venus, because it is easily within reach of a very moderate sized telescope. Probably most observers have considered the study of the planet a hopeless one, but this certainly is not the case. Nothing but diligence and good atmospheric conditions are required to give data of the greatest value, and they are likely to be gathered by some one who seizes the opportunity at the present inferior conjunction of Venus.

We give below a discussion of the periods found by several observers since the time of Cassini in 1667, but will first point out the objections to a period of about one day as stated by several writers. These objections rest on the close agreement of the Cytherean day with our terrestrial day, and the possibility of periodic deception; but those advancing such views evidently have never examined the original records of Schroeter (1789-1795) and are unaware of the fact that the phenomena of the indentation of the southern horn, to which he gave so much attention, scarcely admits of an interpretation based on mere optical illusion. The indentation of the southern horn is very plain under good conditions, and no division of opinion is possible among experienced observers; for I have myself observed this indentation very plainly with the 26-inch refractor at Washington, and made a drawing of it almost identical with those given by Schroeter in the *Philosophical Transactions* of the Royal Society for 1792.

In one of his records Schroeter states (*Philosophical Transactions*, 1895, pp. 117-176) that he saw the indentation plainly disappear after about eleven minutes, and from records made on two successive days found that the Cytherean day is about forty minutes shorter than the terrestrial. In making the second observation on the indentation of the horn, February 27, 1793,

he was unaware of the time recorded on the previous day, and thus all bias or prepossession of mind was avoided.

It must be admitted that a day of 23 hours 21 minutes for Venus cannot easily be explained by a deception. For why should the different observers all reach about the same result, giving a day 35 minutes shorter than our terrestrial day, instead of a day of almost exactly 24 hours? Evidently no good reason can be assigned for assuming that experienced planetary observers such as Schroeter were deceived.

If on the other hand we turn to the modern spectroscopic observations, we find them in conflict among themselves. Belopolski found indications of a period slightly shorter than a day (*A. N.* 3641), while Lowell and Slipher, repeating the observations, got no indications of a rapid rotation (*A. N.* 3891) Schiaparelli's visual observations (*A. N.* 3304) are not as conclusive as one might wish, and Lowell came to reject his early maps of Venus as illusory. (*A. N.* 3823). The only clear evidence that we have therefore is the early observations of Schroeter, which are remarkably convincing; and the later observations of DeVico, which confirm Schroeter's work in every respect. Schroeter found the time of rotation to be 23 hours, 21 minutes, 21 seconds, and DeVico changed this period by less than a second, his final result being 23 hours, 21 minutes, 21.934 seconds.

Finally it may be added that I have detected a theoretical cause which would tend to make the rotation of Venus more rapid than that of the Earth, while that of Mars would be slower; but it is not advisable to go into that at present, and we content ourselves with discussing the old observations and pointing out a piece of work within the reach of an industrious amateur.

U. S. Naval Observatory,
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November 24, 1910.

ON THE MOTION OF SOME OF THE STARS OF MESSIER 92 (HERCULES).*

E. E. BARNARD

The visual micrometric observations of Schultz at Upsala about 1873 of 37 of the brighter stars in the cluster M 92 were

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shown by Dr. Karl Bohlin (Der zweite Sternhaufen im Hercules, Messier 92) to be discordant with his measures of a photograph of the cluster taken in 1898. Discordances as large as 5″ were found by Dr. Bohlin, who attributed them to motion in the stars.

In *A. N.* 4202, I have shown, by comparing the places with my visual measures, that the discordances were probably due, not to motion, but to the difficulty that Schultz must have met with in attempting to measure such small stars with a nine-inch telescope. Many of these stars were observed by him on one night only. The discordances were larger in right ascension, as would be expected from the method used by him, transits by eye and ear.

The importance of possible motion in the component stars of such a cluster is very great, and I have lately made another careful investigation of all of the Schultz stars. For this purpose, I have used two photographs of the cluster made with the forty-inch and a yellow color screen. One of these was made by Mr. Ritchey on June 30, 1901; the other was taken this year, on July 13, 1909 and also one on June 30, 1908. We have, therefore, an interval of eight years to test for motion. The result shows that my previous conclusion was correct and that the discordances found by Bohlin must be due to errors in the early observations. I was led to this further investigation by the fact that a comparison among my visual measures showed decided motion in No. 11. To illustrate this want of motion in the other stars, I have made special measures on these three plates of a few of the stars that, according to Bohlin, gave the largest discordances, besides measuring all of the Schultz stars. Following are some of the results. It will be noted that my interval (8 years) is about one-third of that used by Bohlin. The numbers are Schultz's.

17 — 23.

1901	$\Delta\alpha \cos\delta$	−24″.40	$\Delta\delta$	−27″.41
1909		−24 .34		−27 .41
Difference		0 .06		0 .00

This difference (for 25 years) as given by Bohlin is

9″.5 and 0″.04

or an annual motion in α of 0″.38. For a strict comparison, Bohlin's values should be multiplied by cos δ.

14 — 36.

1901	$\Delta\alpha \cos\delta$	−2′ 56″.99	$\Delta\delta$	+0′ 28″.12
1909		−2 56 .95		+0 28 .15
		0 .04		0 .03

According to Bohlin, this difference was

1″.2 4″.3

7 — 12.

1901	$\Delta\alpha \cos\delta$	—0′ 37″.55	$\Delta\delta$	—1′ 41″.49
1909		—0 37 .52		—1 41 .48
		0 .03		0 .01

Bohlin gives

1″.6 2″.7

3 — 8

1901	$\Delta\alpha \cos\delta$	—1′ 1″.54	$\Delta\delta$	—0′ 45″.87
1909		—1 1 .38		—0 45 .76
		0 .16		0 .11

This seems to show a slight *decrease* in the $\Delta\alpha$.

Bohlin gives

2″.8 1″.2

But he makes the $\Delta\alpha$ to have *increased.*

Several of the other Schultz stars show a possible slight change, but it is too uncertain yet, and can have no meaning with respect to the suggested motions.

These largest motions are therefore disproved. It is evident that if the largest motions can be shown to be fallacious, the smaller ones can have no meaning, and a coincidence with a real motion would be pure chance.

The star 11, as I have said, shows decided motion. It is of the 13.2 magnitude. Bohlin gives for this object for the 25-year interval between Schultz's and his measures

$\Delta\alpha$ —2″.6 $\Delta\delta$ —1″.6

which would give an annual motion of about 0″.1 in 230°.

Following are my visual measures of it, from which I have derived the motion.

My normal star (No. 24?) and No. 11.

1902.56	198°.65	145″.95	(2 nights)
1909.53	198 .75	146 .46	(4 nights)

These give the displacement of 11 in the seven years: amount 0″.576, direction 225°.3.

From this the annual values are:

0″.083 in the direction 225°.3,

or a centennial motion of 8″.3.

These are verified by the photographic results.

From my visual measures its position is

1902.0 α $17^h\ 14^m\ 3^s.75$ δ +43° 12′ 12″.9.

It was measured on the photographs of 1901 and 1909 with reference to some faint stars near it, which, for convenience, I will call *c*, *e*, and *f*. Following are the results:

c — 11.

1901	$\Delta\alpha \cos\delta$	— 8″.63	$\Delta\delta$	+18″.09
1909		— 8 .17		—18 .58

		$e-11$.		
1901	$\Delta\alpha \cos\delta$	+15″.68	$\Delta\delta$	−11″.24
1909		+16 .20		−10 .85
		0 .52		0 .39
		$f-11$.		
1901	$\Delta\alpha \cos\delta$	+23″.58	$\Delta\delta$	− 5″.90
1909		+24 .11		− 6 .38
		0 .53		0 .48

These give the following values for the direction and amount of motion of 11:

With c	direction	226°.8	amount	0″.67
e		216 .9		0 .65
f		222 .2		0 .72
		222 .0		0 .68

The annual motion, therefore, is

0″.085 in RA. 222°.0

(or a centennial motion of 8″.5) which is almost identical with the visual results.

That this motion is in the star 11, is shown by the following comparisons.

		$c-f$.		
1901	$\Delta\alpha \cos\delta$	−32″.21	$\Delta\delta$	+12″.19
1909		−32 .28		−12 .20
		0 .07		0 .01
		$e-f$.		
1901	$\Delta\alpha \cos\delta$	− 7″.90	$\Delta\delta$	−17″.14
1909		− 7 .91		−17 .23
		0 .01		0 .09

The next large motion is in a much fainter star, whose position for 1902.0 is

α 17^h 14^m 9^s.58 $\quad\quad$ δ +43° 14′ 50″.4.

Its proximity to several other and brighter stars makes it difficult visually. From this cause it was not at first measured with the micrometer, though the stars close to it were measured. It is (visually) of the 14.5 magnitude. For the present, we will call it *a*. The following measures will show the motion, which is mainly in declination.

		$a-g$.		
1901	$\Delta\alpha \cos\delta$	+ 9″.72	$\Delta\delta$	− 5″.03
1909		+ 9 .73		− 5 .61
		0 .01		0 .58
		$a-h$		
1901	$\Delta\alpha \cos\delta$	+ 3″.13	$\Delta\delta$	− 1″.80
1909		+ 3 .04		− 2 .34
		0 .09		0 .54

		$a-k$		
1901	$\Delta\alpha \cos\delta$	$-3''.53$	$\Delta\delta$	$-2''.31$
1909		$-3\ .49$		$-2\ .74$
		$0\ .04$		$0\ .43$

These give the following values for the direction and amount of motion in a.

With h	$189°.5$	$0''.55$
g	$180\ .0$	$0\ .58$
k	$174\ .7$	$0\ .43$
	$181\ .4$	$0\ .520$

From which we have the annual motion

$0''.065$ in $181°.4$

or a centennial motion of $6''.5$.

The following comparisons show that the motion is mainly in a.

		$g-k$.		
1901	$\Delta\alpha \cos\delta$	$-13''.25$	$\Delta\delta$	$+2''.72$
1909		$-13\ .22$		$+2\ .87$
		$0\ .03$		$0\ .15$
		$h-k$.		
1901	$\Delta\alpha \cos\delta$	$-6''.67$	$\Delta\delta$	$-0''.51$
1909		$-6\ .53$		$-0\ .40$
		$0\ .14$		$0\ .11$

There is probably a slight motion—which I am investigating—in both h and k.

Conclusion.

There seems to be every reason to believe that in the next fifty years motion will have developed in many of the stars of this cluster and within a few hundred years we shall be able to investigate the laws that control such a great and crowded mass of stars.

There are several cases, which I am investigating, in some of the other clusters that seem to show motion. I have paid more attention to M 92, however, because of Dr. Bohlin's paper on the Schultz stars.

For the convenience of others hereafter, I have prepared a photograph of this cluster (M 92) to accompany this paper.* On this are marked the Schultz numbers, and also the letters for the comparison stars for 11 and for a. The sides of this plate are very closely oriented. The normal star for all my investigations of this cluster is possibly Schultz 24 (*A. N.* vol. 176, page 22). Being in the dense part of the cluster, it is indicated by a straight line running from the star to the number 24.

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*See Frontispiece.

THE INFLUENCE OF SUN-SPOTS UPON CLIMATE.

ANDREW H. PALMER

For POPULAR ASTRONOMY.

Considerable speculation has been indulged in within recent years as to the terrestrial influence of sun-spots. While few investigations have been made attempting to measure this relation, if such exists, many conjectures of various kinds have been offered from time to time. Certain influences of these solar activities upon the Earth have been perfectly demonstrated. For example, the astronomer, R. Wolf, of Zurich, has shown through a superposition of curves that the number and violence of magnetic disturbances upon the Earth varies directly as the number of sun-spots. More recently, Dr. Ellsworth Huntington of Yale, in the *Popular Science Monthly* for June, 1908, has pointed out the close relationship between telluric activity and sun-spot numbers, basing his conclusions upon data gathered by Mr. R. W. Sayles of Harvard and Mr. Jensen of New South Wales. The latter study seems to point to the conclusion that telluric activity varies in amount and intensity inversely as the number of sun-spots.

But perhaps the most interesting influence yet ascribed to sun-spots is that of an influence upon the meteorology and climatology of the Earth. As far back as 1879, Mr. G. M. Whipple in the *Quarterly Journal* of the Royal Meteorological Society remarked incidentally, in dealing with cloudiness data obtained at Kew Observatory, England, that "they appear to indicate a tendency to a periodicity akin to sun-spot variations, the relatively clear sky period coinciding with a year of maximum, and the years of more cloud with minimum sun-spot periods." Again, Professor C. A. Young in his "General Astronomy" refers to the researches of Mr. Meldrum, of Mauritius, who found a connection between the cyclones of the Indian Ocean and solar activities in the form of sun-spots. Moreover, he also refers to the study of the meteorological records of the Argentine Republic made by Dr. Gould showing "an indubitable connection between the wind currents and the number of sun-spots." From time to time other attempts have been made to show that parallel with the eleven-year period in the sun-spot numbers, there are fluctuations in the temperature, barometric pressure, and rainfall at the surface of the earth. It appears that in some parts of the

Earth the variations in the meteorological conditions, though slight, have been directly and in other parts inversely as the number of sun-spots.

Recent researches based upon the observations made at Blue

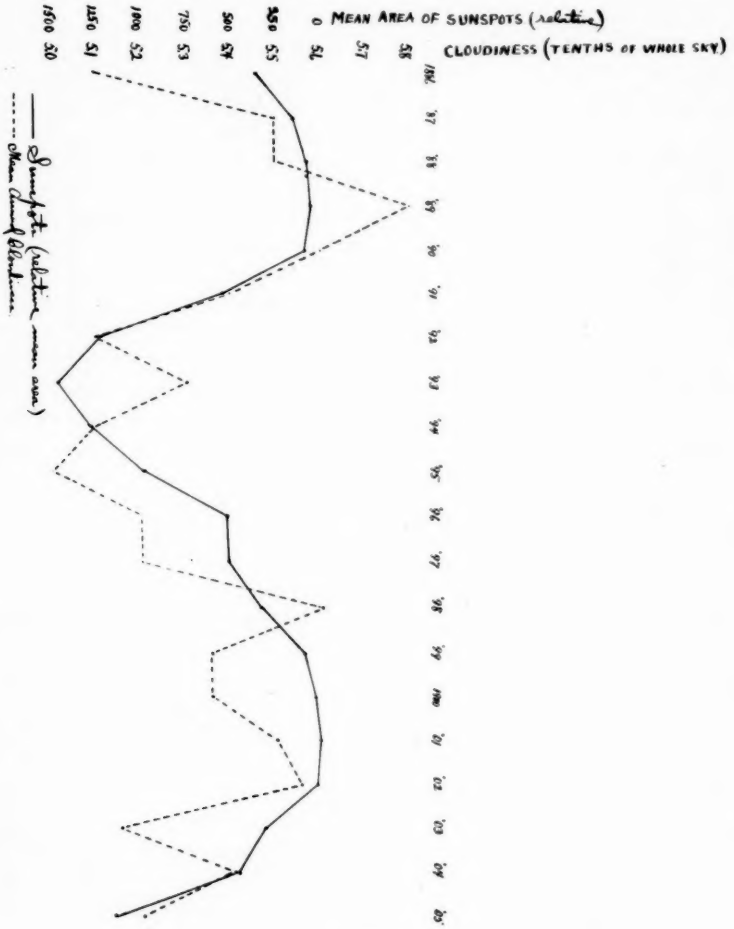

FIGURE 1.

The Relation of Sun-Spots to Cloudiness as observed at Blue Hill Observatory.

Hill Observatory during the period of twenty years from 1886 to 1905 inclusive, have given some interesting results in this connection. The observations used in these studies are particularly

adapted for such use because of the unchanged condition, during all of that time, of the exposure of the instruments and of the environment of the observatory itself, and also because of the fact that practically all of the observations were taken by but three different men, thus insuring against error in the form of personal equation. Moreover, in the case of the mean cloudiness for the year, the records of the observatory are of particular value, because of the fact that, so far as is known, they are the only records of cloudiness in the United States where the amount of cloud for each one of the twenty-four hours has been kept for so long a period of years, or is being obtained at the present time.

As shown in Figure 1, there seems to be a well-defined relation between sun-spots and cloudiness as observed at Blue Hill Observatory. The sun-spot data here used are those of sun-spot areas (which vary directly as sun-spot numbers) given in "The Science Year Book" for 1908, while the cloudiness is the mean for each year, expressed in tenths of the whole sky, computed from daylight eye observations and night pole-star records of cloudiness obtained at the observatory. While the mean cloudiness curve is not so smooth as that of sun-spots, the two curves show the same general characteristics. Bearing in mind the fact that the superposition of the curves is a purely arbitrary one, and that the scale for the sun-spot curve runs in the opposite direction from that of the cloudiness curve, it may safely be said that there is a close connection between the two phenomena, and that the relationship is not an accidental one. It is to be noted also that the relationship is an inverse one, similar to that Mr. Whipple found in his study, referred to above.

The close connection between cloudiness and rainfall naturally would lead one to believe, *a priori*, that the same general relation would be found between sun-spots and rainfall as it is shown above appears to exist between sun-spots and cloudiness. In Figure 2, the relationship is seen in the same general tendency of the curves, which, although they do not coincide as closely as those of Figure 1, show similar characteristics, nevertheless, Of course, in both figures glaring exceptions can be found for individual years, but as a whole the curves seem to show a general coincidence.

The comparison with sun-spots was extended to the mean temperature and the mean pressure for each year of the twenty here considered, but no agreement was found, there being ap-

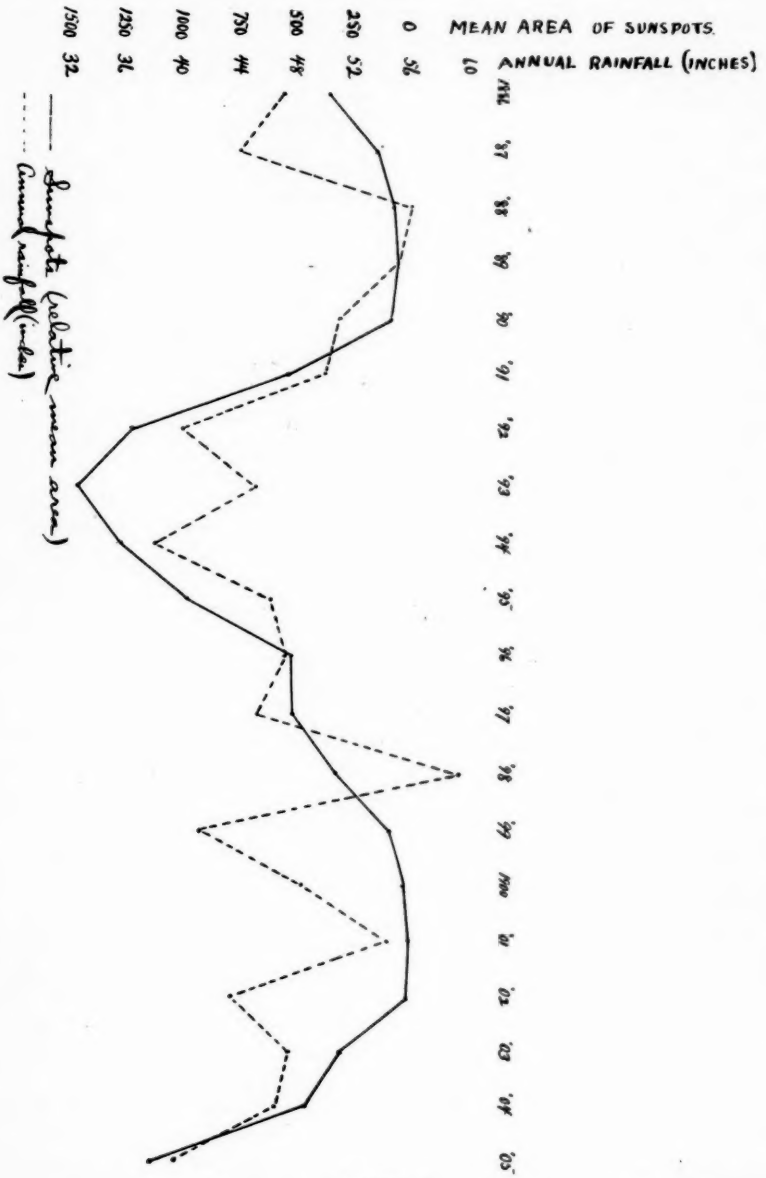

FIGURE 2.
The Relation of Sun-Spots to Rainfall as observed at Blue Hill Observatory.

parently no period of approximately eleven years for these meteorological elements. Nor was a relation found between wind direction or velocity and the sun-spots.

TABLE SHOWING AREAS OF SUN-SPOTS, MEAN CLOUDINESS, AND RAINFALL FOR THE PERIOD, 1886 TO 1905, INCLUSIVE.

	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895
SUN-SPOTS RELATIVE MEAN AREA	579	301	236	131	304	1412	3270	2404	1877	2278
MEAN CLOUDINESS (10THS.)	5.1	5.5	5.5	5.8	5.6	5.4	5.1	5.3	5.1	5.0
INCHES OF RAINFALL	47	44	56	55	51	50	40	45	38	46

	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905
SUN-SPOTS RELATIVE MEAN AREA	1410	1149	891	337	180	29	172	970	1761	2612
MEAN CLOUDINESS (10THS.)	5.2	5.2	5.6	5.35	5.35	5.50	5.55	5.15	5.40	5.20
INCHES OF RAINFALL	47	45	59	41	48	54	43	47	46	39

It was suggested that the close connection between cloudiness and sun-spots was due to the impossibility of observing sun-spots during periods when the photosphere is obscured by cloud. This suggestion does not explain the relation, however, as the sun-spots were observed in England while the meteorological data were obtained in Massachusetts.

Whether or not the close relationship of cloudiness and rainfall to sun-spot numbers is a universal one cannot now be stated. However, it is sufficient to say that such a relationship exists at Blue Hill. Moreover, it cannot even be demonstrated that the changes in these meteorological conditions at the Earth are the results of activities upon the solar photosphere or whether the coincidence is the harmonic pulsation, as suggested by Dr. Huntington, caused by a force external to both Sun and Earth. Nevertheless, the field offers unlimited opportunities to the careful investigator, and it is not improbable that future research may discover relationships and invent explanations heretofore unthought of.

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DISTANCES AND MOTIONS OF THE STARS.

ARTHUR K. BARTLETT

For POPULAR ASTRONOMY.

The problem which astronomers have to solve in ascertaining the distances of the stars, is one of the most stupendous difficulty, and not until within a comparatively recent time have any satisfactory results been attained to reward the careful observations of centuries. Of all the thousands of stars that have been studied, astronomers know the distances of about 100, and even these are known only approximately, being the supposed distances within which they cannot be, but beyond which they must be, though the exact limits cannot at present be determined, owing to the immense intervals which separate them from our Earth. The nearest star is so remote that its light requires 4 1-3 years to reach us, while the light of the pole star is forty-five years in traveling to us from that distant orb; so that if the light of this star was suddenly extinguished to-day, nearly half a century would have to elapse before we should be aware of the fact, and miss the familiar orb from its prominent position in the northern heavens.

The mathematical principles involved in determining the distance of a star are essentially the same as those employed by a surveyor when he wishes to measure the width of a stream which he cannot cross, only with the astronomer the problem is rendered much more difficult from the fact that he is unable to procure a base line of sufficient length to meet his requirements, and even the diameter of the Earth's orbit is not great enough to use in measuring the distances of the stars, with very few exceptions. To learn the distances of the stars it is first necessary to determine what is known as a star's parallax, or its angle of direction when viewed from two opposite points in the Earth's orbit, and this is what renders the problem so extremely difficult; for nearly every star that has been examined for the purpose of learning its distance has failed to show any parallax whatever, and in the few distances where a parallax has been recognized, the angle is found to be exceedingly small. No star, yet known, in the heavens has a parallax equal to one second of arc, but all thus far determined are below even this small angle. The "annual parallax" of a star is the angle under which the semi-diameter of the Earth's orbit would appear as viewed from the star.

The value of a second is so small that a spider's web, placed in the field of view of a telescope, completely hides the portion of the celestial sphere where the apparent movements of the stars are effected—a portion at most equal to not quite one second. The reader will therefore be able to realize the difficulty of the problem which is presented to astronomers for solution. A parallax of one second means that the celestial object is 206,265 times farther away than we are from the Sun, the Sun's distance being one-half of the base line, or about 93,000,000 miles. If, then, a star's parallax be less than one second, the star must be farther away than 206,265 times 93,000,000 miles, and this we find to be the case with every star in the heavens that has been studied this way. By the orbital motion of the Earth around the Sun, our position with respect to the stars is changed proportionately less than would be that of a grain of dust placed in the middle of the dome of St. Paul's cathedral in London, if it were made to whirl around in a circle having a diameter of $^{1}/_{100}$ of an inch. Investigations are now in progress which promise greatly to extend the list of stars having a measureable parallax, and it is possible that the distances of most of the naked-eye stars may be ascertained before many years have elapsed.

The star which gives the greatest parallax of any, and is believed to be the nearest to our earth, is Alpha Centauri, a bright, first-magnitude star in the southern heavens, and never visible in our latitude. But even this star's parallax is only $^{75}/_{100}$ of a second, which corresponds to a distance of 275,000 times the Sun's distance from our Earth, or nearly 25 trillions of miles! The angle or parallax of Alpha Centauri is equal only to the 400th part of a second space on the face of a watch, and this, it should be remembered, is the nearest star at present known to astronomers, excepting of course our own Sun, which is also a star among the thousands that adorn the firmament. The nearest stars exhibit the largest parallax, but no case has yet been found in which this quantity is as great as a foot rule seen at a distance of fifty miles, and only for comparatively few stars is it certainly appreciable.

The Earth's orbit, seen from Alpha Centauri, would appear the same as a circle six-tenths of an inch in diameter, viewed at the distance of one-mile; and the radius of that orbit (the distance which separates our Earth from the Sun) would be hidden by a fine thread, or spider's web, one twenty-fifth of an inch in diameter, held 650 feet from the eye! In other words,

a line 186,000,000 miles long, looked at broadside, would shrink into a mere point; and if our Sun were removed to that enormous distance, it would shine with a light only equal to that of the "north star." The Moon's average distance from the Earth is known with an uncertainty of perhaps twenty miles, and we at present know the Sun's distance to within a thousandth part of its actual amount, but no such degree of accuracy can be claimed when we attempt to express the distances of the stars, which must be hundreds of thousands of times farther away from us than the Sun. A recent writer on the subject has well remarked: "Many of the problems which the devotees of stellar science seek to solve possess a fascination for thousands of educated persons, but none of them has provoked more eager curiosity than the probable distances of the stars." There are some stars so remote that their light, though traveling with a velocity of 186,000 miles per second, cannot reach us in less than 10,000 years. To traverse the Milky Way, of which our own solar system forms a part, light requires 25,000 years.

To ordinary vision, all the stars appear at rest in our heavens; nor can the astronomer himself recognize any signs of motion, except by patient and long-continued observation, extending, in some instances, over a period of many years, and even centuries when succeeding astronomers complete the work which their predecessors had begun. But every star in the firmament is on its journey, and moving through space with a wonderful velocity. Absolute rest is unknown throughout the material universe. If we look up to the sky on a calm, bright night, when the stars shine in all their glory, we are usually impressed with the feeling that a solemn stillness reigns throughout those infinite regions of space. In reality, those amazing star depths above us, which appear so steadfast and unchangeable from year to year, are astir with life, energy, and activity, and there is a remarkable process of change taking place all around us. It is believed by many astronomers that the Sun, with its entire family of planets and comets, is moving with great velocity toward the constellation Lyra; and quite recently it has been announced that the immense nebulae, or "star clouds," have also been found to be in motion.

Some stars are known to be approaching, and others receding from, the Earth. Among those found to be approaching us is Arcturus—mentioned in the Bible, and the brightest star north of the equator—which is moving with a velocity of 55 miles every second. Sirius, the "Dog-Star," so glorious on

winter evenings, and the brightest star in the heavens, is receding from us at the rate of 26 miles a second; and yet, even with these enormous velocities, the passage of a thousand years will make no perceptible difference in the appearance of these two stars, so immense are the distances which separate them from our Earth.

The great velocity that has been recognized among the stars until quite recently, is found in the motion of a small star near the north pole known as "No. 1830 Groombridge," or the "Runaway Star," as it is sometimes called, which is believed to be rushing through space at the rate of 232 miles per second. This star appears to be moving in a perfectly straight path through the sky, and it may be visiting our stellar system for the first time; but whence it came, or whither it is going, no one can tell, and it is a great enigma to astronomers. Its wonderful velocity cannot be explained, as it is greater than could be produced by the influence of all the known bodies in the universe; and on the other hand, the combined attraction of all the stars cannot stop this wanderer in its solitary flight through space, until it has rushed on to the extreme limits beyond which the greatest telescopes have never penetrated. It has been mathematically demonstrated that a body approaching the center of our system, from an infinite distance, cannot move with a greater velocity than 25 miles a second, if influenced by the atraction of the masses in our universe alone; but here we have been considering a star moving with eight times that velocity, and still, notwithstanding the fact that its motion was for a long time the greatest known among the stars, it would require 185,000 years for this remarkable star to complete an entire circuit around the heavens.

It was recently discovered that the star Mu in Cassiopeia has a velocity of 305 miles a second, while, if the observations of Dr. Elkin are to be accepted, Arcturus is traveling toward the Earth at a speed of 375 miles a second. These are the greatest velocities at present known among the stars, but motions even more rapid and startling will doubtless be announced in the near future. It has recently been found that a small star of the eighth magnitude, invisible to the naked eye, and located in the southern hemisphere, known as the "galloping star," exhibits the greatest proper motion observed in the heavens, even exceeding the wonderful velocities mentioned above, which seems almost incredible and cannot be accounted for by any force in the visible universe known to astronomers at the present time.

These motions observed among the stars are owing to the attractive influence which they exert upon each other. But the whole of their "proper motion," as it is called, is not real, a part of it being apparent only, and due to the real, or proper motion of the Sun, together with the entire planetary system. Our great universe of stars is constantly undergoing vast changes, which will be preceptible to those who inhabit the Earth in future centuries. The configurations of our starry heavens will eventually be greatly changed from their present appearance. Orion, now so beautiful and attractive during the winter season, will then no longer hold supremacy over the constellations. The well-known "Big Dipper" will sometime, in the distant future, assume a very different appearance from that now presented to our view, and must finally cease to attract the attention of "star-gazers," as it does at present, by the beauty of its familiar figure in our northern sky.

One of the most notable examples of the constant and yet almost imperceptible changes taking place in our firmament, is to be found in the motions of the seven bright stars forming the "Big Dipper," above mentioned, in the constellation Ursa Major. Dr. Huggins, the eminent English astronomer, has found, by means of the spectroscope, that five of these stars are moving in the same direction, with nearly the same velocity, and receding from the Earth at the rate of about twenty miles per second, which seems to indicate that they are associated with each other in some mysterious way at present unknown to astronomers. The late Professor Proctor referred to them as the "drifting stars," and this community of motion, where groups of stars appear to be traveling as systems, he termed "star-drift," of which there are many interesting examples to be found in various parts of the heavens.

After a careful and long-continued study of the motions of the seven stars in the "Big Dipper," Professor Proctor was able to represent the outlines formed by them at various times in the past, and those which they will form in the distant future. One hundred thousand years ago, according to his ingenious calculations, the stars now forming the familiar "Big Dipper" were arranged in the outline of a large and irregular-shaped cross; and one hundred thousand years hence, they will assume the outline of an elongated and inverted "Dipper" (very different from the one we now see), which will stretch over a large extent of the sky, and the two "Pointers," now so convenient to casual observers of the heavens, will then no longer indicate the

position of the "pole-star," as they do at present, for there are no "fixed stars," and each one of those distant suns, flaming in the immensity of space, is swept along in a movement so rapid that the human mind can hardly conceive it, and almost grows weary even in its contemplation.

Battle Creek, Michigan.

THE BLACK DROP.

A. B. ANDREWS

For Popular Astronomy.

The "Black Drop," so called, is a phenomenon noticed during transits of Venus. It consists of a black ligament, apparently joining the edges of Venus and the Sun at second contact. This has rendered the time of second contact uncertain, within a second or two, and has destroyed all value of the transit of Venus, as an exact method of determining the Earth's distance from the Sun. This ligament may, at any time, be very easily reproduced, by touching one's two thumbs together, in front of a light. The writer has conducted a series of experiments to reproduce artificially the "Black Drop," and to determine the precise instant, at which the two circumferences are tangent.

A short description of the apparatus used will be necessary. To represent the Sun, a disk of ground-glass, eight inches in diameter was used. Behind this was placed a 90° arc-lamp, using eighteen amperes of current at 110 volts. The lamp was situated at a distance of ten inches, in a line perpendicular to the center of the glass. The illumination of the disk, resembled that of the Sun, in that it was softly shaded, from the center to the edges. In front of this disk was a pair of brass semicircles with very smooth edges and with their circumferences facing each other. These circles formed part of an electric circuit, in series with a battery and telephone. The right-hand circle was mounted on a threaded axis, so that it could be made to approach or recede from the other; at a distance of fifty feet was placed a telescope of 100 mm. aperture, using a low power with a sun-glass, and in line with the center of the artificial sun.

Everything being in readiness, the arc-lamp was started and the circles separated about 3 mm. After focussing carefully, the edges of the circles were very sharply defined and absolutely smooth. An assistant then screwed the circles together until a click was

heard in the telephone indicating that the circles were in contact. No sign of the "Black Drop" appeared at any time the only noticeable effects being the phenomena of diffraction, as the circles came very close together. On again separating the circles, no trace whatever of a connecting ligament could be found. These operations were several times repeated, with a negative result, however, and no change in the power of the eyepiece would bring the ligament to view.

The telescope was now placed slightly out of focus and the movements repeated. This time the ligament made its appearance. As the circles approached each other, the hazy outlines mingled slightly, until, with the suddenness of an occultation, the ligament apparently jumped the gap. It was, however, only apparently, for, synchronously with the appearance of the ligament, the telephone sounded. On re-focusing, the disks were seen to be in contact, although, when out of focus, they appeared to be separate and connected by the ligament. On again putting the telescope out of focus and separating the disks, at the instant the ligament disappeared, the telephone sounded, showing that the circuit was broken. The very slightest movement of the screw, sufficed to render visible or destroy the ligament and the very slightest maladjustment of focus, makes it possible. This may be illustrated by holding the thumbs close together, before a light and touching them. If the eye be focussed on the thumbs, only a small ligament will be seen, caused by their roughness. If, however, the eye be focussed on the light, a very prominent ligament is observed.

Now, as to the actual conditions in the heavens, when in focus, the Sun, through a telescope, appears, as though it were a region of light, surrounded by an opaque diaphragm, with sharp and well-defined edges. This idea, of the Sun being an opening in an opaque diaphragm, is the one it is wished to present.

Venus, when in transit and in focus, has a round well-defined disk. Now, seen from the Earth, the distances of Venus and the Sun, are, roughly, in the ratio of 25 to 93. Evidently, the points of exact focus for the limb of Venus and the inner edge of the "Diaphragm" will vary slightly. That is, if one is in exact focus, the other is not and this difference will be enough to produce the "Black Drop." If these conditions are analogous to those of the experiment, the instant of second contact is the instant at which the ligament starts to break.

Against this may be urged the fact that after the ligament has broken Venus appears to be some little distance over the

edge of the Sun. This admits of a very simple explanation. The instant after the ligament breaks, or second contact, a very narrow line of the Sun's limb becomes visible. This edge, standing out in contrast with the black sky and the black disk of Venus, is, owing to the well-known effect of irradiation, made to appear many times as wide as it actually is, and if, as is unavoidable, either the Sun or Venus, is in the slightest degree out of focus this effect would be magnified.

Another result of this experiment, is, that the ligament is the more prominent and objectionable, the more intense the light. Possibly, if during future transits, eyepieces are used transmitting only light enough to render vision distinct the trouble from this source may be minimized, although, owing to the above mentioned difference in focus, it will, probably, never be entirely eliminated. It is to be hoped that further experiments will shed more light upon this perplexing question.

32 High St.,
Auburn, Maine.

THE SUN, MARS, JUPITER AND THE MOON WITH A SMALL TELESCOPE.

JOHN A. RAPP

For Popular Astronomy.

During the first half of 1909, I observed the Sun to a considerable extent and I have quite a collection of drawings.

On January 24, there were several groups of spots near the east limb. From day to day I watched these spots as they slowly appeared to approach the center of the solar disk. The four principal groups formed the shape of a rectangle, and each day I observed changes in this rectangle, the groups, and the spots themselves.

On the 27th, I counted about fifteen spots in one of these groups, and near the west limb, the bright faculae were distributed over a considerable area. These appeared branched and irregular in form, and much brighter than the rest of the surface although I do not think that I ever saw them except near the limb.

By employing a lower power, I could also detect the minute granules which are rather hard to see under ordinary circumstances.

The 'rectangle' before mentioned gradually moved toward the

west limb, the spot groups had changed greatly, and on the 7th of February, there was but one spot visible. I could find no spots for two days after, but one appeared on the east limb on the 10th.

I made drawings of several of the larger spots with a power of about 200, and there were surprising changes in one or two days. The accompanying drawings show the change in a group of spots between April 22^d 18^h, and 23^d 4^h, or about ten hours. Some of the spots have a hazy outline while others appear sharp and black. In several sun-spots I have noticed that the edge of the penumbra is somewhat darker than the space adjoining

FIGURE 1.—April 22^d 18^h

FIGURE 2.—April 23^d 4^h

SUN-SPOTS.

the umbra, and I have also seen a white spot in the interior of the umbra. For about four months I was able to observe sun-spots on every clear day except the two days mentioned above, on which I could not find a single spot.

On account of the favorable opposition of Mars which occurred in September, this planet was my favorite object of study during the summer and autumn. I began observing the planet in May, and the south polar cap was plainly visible at that time. To me it appeared to have a diameter of at least one-

sixth the diameter of the disk, or upward of 700 miles. I occasionally saw it when the planet was almost obscured by clouds. Along the edge of the cap a dark streak or belt was visible, and toward the center of the disk was a dark, irregular area which did not seem very distant to me.

FIGURE 1.—Mars
Drawn June 17d 16h, 1909

The first disk of the drawings shows the south polar snow cap and the marking as it appeared to me in the early summer. At that time the planet showed a phase something like the Moon when within three days of full.

The opposition of Mars occurred on the 24th of September, and some time before and after that date the disk of the planet appeared perfectly circular as is shown in the second disk of the drawings. The polar cap had shrunk considerably in size, and I was now able to see markings extending almost across the disk, where I had seen, three months before, only a small spot.

Surrounding the polar cap, was a dark belt and below this, a broad white area which was bordered by another more distinct dark belt. On the lower edge of this belt I noticed several

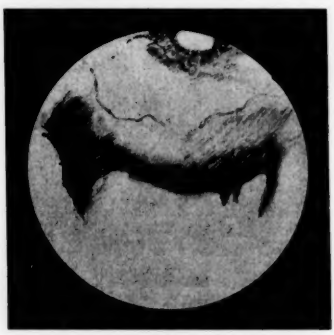


FIGURE 2.
Drawn Sept. 26d 7h—9h, 1909

FIGURE 3.
Drawn Nov. 15d 9h—10h, 1909

projections, which at times appeared quite sharp and distinct but they generally required favorable conditions to be well seen. I easily recognized the great projection known as Syrtis Major, but the others were not so readily seen. These mark-

ings appeared to be much darker near the lower edge and gradually became fainter toward the polar cap.

The white belt near the pole seemed to be, at times, almost as luminous as the snow cap itself. As the planet revolved, different markings appeared and what was visible in the evening was invisible the next morning. I made the first drawing in the morning, because at that time Mars was not visible in the evening, but the other two were drawn in the early evening, in September and November.

In the early part of the latter month the polar snow cap was scarcely visible in my instrument. At this time it appeared as a minute white spot, surrounded by what appeared to me as a whitish cloud. Below this was a narrow dark streak bordered by the same kind of white belt seen in September. The dark area beyond this belt was long and narrow with one or two small projections. The seeing in November was generally bad and I was not able to draw the spots as well as in September.

The planet Jupiter was also an interesting object of study. Of course I easily saw the dark belts and the moons, as these are conspicuous, and I observed many transits, eclipses, etc., of the satellites. At favorable times I also saw a whitish spot near one of the belts, but never very distinctly. Occasionally a satellite would cross a dark belt and then appeared as a small bright disk, but at other times only the shadow was visible.

I consider the Moon a grand object of study with a common telescope, and I have devoted much of my time to this interesting subject. On exceptionally fine nights I use a power of 200 and this shows a great amount of detail. It will require much study to locate all the formations described and shown in the text-book I am using.

The telescope I used has a clear aperture of 2¾ inches, and a focal length of 42 inches, with powers of 30, 45, 80, 100, 140 and 200 diameters. I am an amateur, and would like to correspond with others.

Morton, Illinois.

November 24, 1909.

ORIGIN OF THE LUNAR TERRESTRIAL SYSTEM BY CAPTURE, WITH FURTHER CONSIDERATIONS ON THE THEORY OF SATELLITES AND ON THE PHYSICAL CAUSE WHICH HAS DETERMINED THE DIRECTIONS OF THE ROTATIONS OF THE PLANETS ABOUT THEIR AXES.* II

T. J. J. SEE

VI. Darwin's graphical method of representing the past history of the Earth and Moon under the secular action of tidal friction.

On account of the high importance of realizing fully the great strength of the celebrated graphical method which Darwin developed at the suggestion of Sir W. Thomson, as well as the weakness underlying the interpretation of it heretofore adopted, it becomes necessary to explain briefly the fundamental equations with the accompanying diagram.

Let M be the mass of the Earth, m that of the Moon, Ω the angular velocity of the two bodies about their common center of gravity, the orbit being supposed circular. Introduce a special system of units designed to reduce the analytical expressions to their simplest forms, and take the unit of mass to be $\frac{Mm}{M+m}$, the unit of length γ to be such a distance that the moment of inertia of the planet about its axis of rotation shall be equal to the moment of inertia of the Earth and Moon, treated as particles, about their center of inertia, when distant γ apart from each other. Then if C be the Earth's moment of inertia about its axis of rotation, we shall have

$$\left.\begin{aligned} M\left(\frac{m\gamma}{M+m}\right)^2 + m\left(\frac{M\gamma}{M+m}\right)^2 &= C \\ \text{or} \qquad \gamma &= \left(\frac{C(M+m)}{Mm}\right)^{\frac{1}{2}}. \end{aligned}\right\} \quad (1)$$

Take for the unit of time τ the interval in which the satellite revolves through $57^\circ.3$, when the satellite's radius vector is

*From *Astro. Nach.* 4343.

equal to γ; then $\frac{1}{\tau}$ is the orbital angular velocity, and by Kepler's law of periodic times,

$$\tau^{-2}\gamma^3 = \mu(M+m) \tag{2}$$

where μ is the attraction between unit masses at unit distance.

Substituting for γ its value in (1), we get

$$\tau = \left(\frac{C^3(M+m)}{\mu^2(Mm)^3}\right)^{\frac{1}{4}} \tag{3}$$

This special system of units makes each of the following expressions unity:

$$\mu^{\frac{1}{2}} Mm\,(M+m)^{-\frac{1}{2}};\ \mu Mm;\ \text{and } C.$$

The moment of momentum of orbital motion, in a circular orbit of radius r is

$$M\left(\frac{mr}{M+m}\right)^2\Omega + m\left(\frac{mr}{M+m}\right)^2\Omega = \frac{Mm}{M+m}r^2\Omega. \tag{4}$$

And Kepler's law gives

$$\Omega^2 r^3 = \mu(M+m),\ or\ \Omega r^2 = \mu^{\frac{1}{2}}(M+m)^{\frac{1}{2}} r^{\frac{1}{2}}. \tag{5}$$

Therefore, by means of the special units, the moment of momentum of orbital motion in (4) becomes

$$\mu^{\frac{1}{2}} Mm\,(M+m)^{-\frac{1}{2}} r^{\frac{1}{2}} = r^{\frac{1}{2}}. \tag{6}$$

The moment of momentum of the Earth's rotation is Cn, where C is the moment of inertia and n the angular velocity of rotation. The total moment of momentum of the system is constant, and made up of two parts, one depending on the rotation of the Earth about its axis, the other on the orbital motion of the two bodies about their center of inertia; therefore if h be this constant, we have in the special units

$$h = n + r^{\frac{1}{2}}. \tag{7}$$

The kinetic energy of orbital motion is

$$\frac{1}{2}M\left(\frac{mr}{M+m}\right)^2\Omega^2 + \frac{1}{2}m\left(\frac{Mr}{M+m}\right)^2\Omega^2 = \frac{1}{2}\frac{Mm}{M+m}r^2\Omega^2 = \frac{1}{2}\frac{\mu Mm}{r}. \tag{8}$$

The kinetic energy of the Earth's rotation is $\frac{1}{2}Cn^2$, and the potential energy of the system is $-\mu\frac{Mm}{r}$. The sum of these three energies, in the special units, becomes

$$2e = n^2 - \frac{1}{r} \tag{9}$$

Putting $$x = r^{\frac{1}{2}},\ y = n,\ Y + 2e \tag{10}$$

Darwin has illustrated these fundamental equations and another called rigidty, which gives the condition the two bodies should revolve as parts of a rigid system:

Momentum, $$h = y + z \tag{11}$$

Energy, $$Y = y^2 - \frac{1}{x^2} = (h - x)^2 - \frac{1}{x^2} \tag{12}$$

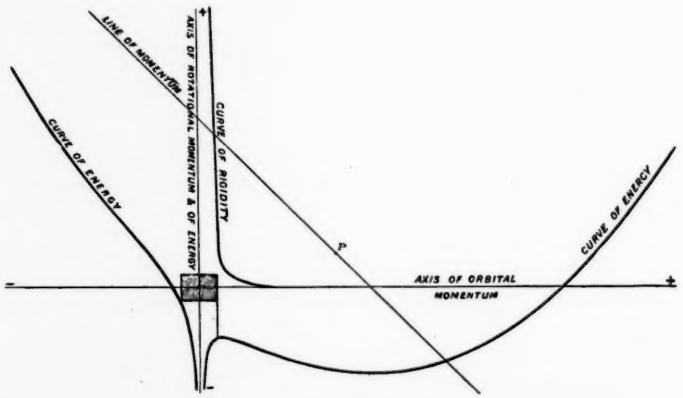
Rigidity, $$x^3 y = 1. \tag{13}$$

Equation (11) is the equation of conservation of moment of momentum; (12) the equation of energy; (13) that of rigidity. When the system is once started, h remains rigorously constant under the interaction between the two bodies, Y degrades, and the curve of energy has maximum and minimum values defined by the condition

$$\frac{\delta Y}{\delta x} = 0 \text{ or } x^4 - hx^3 + 1 = 0. \tag{14}$$

Taking the Moon's mass to be $\frac{1}{82}$ of the Earth's mass, and the Earth's moment of inertia as $\frac{1}{3}\ Ma^3$, Darwin found the special unit of mass to be $\frac{1}{83}$ of the Earth's mass, the unit of length 5.26 radii of the Earth (33,506 kilometers), and the unit of time $2^h\ 41^m$.

In these units the present angular velocity of the Earth's rotation becomes 0.7044 and the Moon's radius vector 11.454. This position of the Moon is indicated in the diagram by the point P, and the moment of momentum of its orbital motion is



3.384, and thus very large. This is Darwin's celebrated analysis of the interaction of the Earth and Moon (cf. Proc. Roy. Soc., June 19, 1879; also Thomson and Tait's Nat. Philosophy, Appendix G; or Encyclopedia Britannica, Article "Tides").

As the energy curve has a maximum near the origin, corresponding to a small distance between the Earth and Moon, Darwin inferred that they had once been a single mass, rotating temporarily as a rigid system; and that after the separation, the Moon had receded, according to the downward slope of the energy curve, till it reached its present distance. The time of the Earth's rotation was calculated to be $2^h\ 41^m$, which would barely enable the equilibrium of the globe to maintain its stability under gravity. And as this pointed to the rupture of the globe from too rapid rotation, Darwin inferred that it had actually occurred, and that the Moon had thus been detached from the Earth.

Nolan and others pointed out the extreme difficulty the Moon would have in holding together under tidal strain within so small a distance of the Earth; and the inevitable disruption of such a satellite within 2.44 radii of the planet had been well established by the earlier researches of Roche and the subsequent investigations of Darwin. So long as it was uncertain whether the Moon could hold together so near the Earth, it was for a time believed that the primeval satellite might have taken the form of a flock of meteorites when the separation first took place. The difficulty of making out how the Moon got started as a single mass so near the Earth, Darwin has repeatedly acknowledged. As the result of Nolan's criticism, he found 6,500 miles from the center of the Earth to be the minimum distance at which the Moon could revolve in its entirety (Phil. Trans., vol. 178, 1887, p. 416); but this was not entirely satisfactory, and at the end of his important paper on the figures of equilibrium of rotating masses of fluid (Phil. Trans., vol. 178, 1887, p. 422) he concluded in some despair that it is necessary to suppose that, after the birth of a satellite, if it takes place at all in this way, a series of changes occur which are quite unknown.

Accordingly we see that by tracing of the Moon back towards the Earth, this supposedly reversed process brought them into close contiguity, one rotating and the other revolving in approximately the same time, and both not far from the critical period of instability for the terrestrial spheriod. "Is this," asks Darwin, "a mere coincidence, or does it not rather point to the

break-up of the primeval planet into two masses in consequence of a too rapid rotation?" In addition to the objections already advanced, another formidable one arises from the difficulty of finding any cause adequate to produce the supposed very rapid rotation of the primitive globe. This objection is now recognized to be much greater than it was supposed to be when Darwin's work was finished thirty years ago; for Laplacian conceptions were then universally prevalent, and it was natural to think of the Moon as a part of the Earth, while such an idea as the capture of satellites would not have been entertained. In the views current thirty years ago, the above question of Darwin was naturally answered in the affirmative, in spite of outstanding difficulties of considerable magnitude. To-day with all the other satellites, proved to be captured, the wonderful relations brought out by Darwin's analysis must be declared to be of an accidental but most deceptive coincidence. It is probably the most remarkable result of this kind in the annals of science.

VII. On Stratton's researches on planetary inversion.

In the *Monthly Notices* of the Roy. Astr. Soc. for April, 1906 (vol. 66, no. 6), Mr. F. J. M. Stratton, of Cambridge, England, has a scholarly discussion of the problem of planetary inversion, which had been suggested by Professor W. H. Pickering's discovery of the retrograde motion of Phoebe, and the tacit assumption formerly adopted by all writers that the satellites have been detached from the planets about which they revolve.

In stating his problem Mr. Stratton says: "If, then, a satellite were thrown off in a very early stage of the planet's evolution, it would commence moving in a retrograde direction around the planet. If the oblateness of the planet were very small, or the satellite at a considerable distance from the planet's center, the plane of the orbit of the satellite would not follow the plane of the planet's equator as it tilted over, but would fall back into a stable position near the ecliptic—a term used in this paper for the plane of the planet's orbit. Such a satellite would remain of the retrograde type exemplified by Phoebe. If, however, the satellite were evolved in a later stage of the planet's development (after the planet had greatly contracted and become more oblate), the satellite would move in an orbit whose stable position was almost coincident with the planet's equator, and the satellite would follow the planet's equator. Most of the known satellites of the solar system fall into this class.

Professor Pickering urged in support of this view that the classical nebular hypothesis, according to which the planets were thrown off in the form of rings, required an initial retrograde rotation of the planet and not a direct one, as Laplace assumed. But of recent years Sir George Darwin, Professor T. C. Chamberlain, and Dr. F. R. Moulton have adduced strong reasons for discarding the ring-theory, and it would seem that such confirmation as it would undoubtedly have given to this investigation must for the present be disregarded. Though apparently the classical form of the nebular hypothesis cannot now be accepted without considerable modifications I have here followed it in general as regards the history of the planetary subsystems, and have assumed a planet to be a gradually contracting body, which from time to time may pass through a form of instability, resulting in the evolution of a satellite."

Mr. Stratton found many difficulties and uncertainties in this work and has discussed them fully. On pages 396-8 he has the following remarks: "There remains one other difficulty in connection with the time required for the working out of the theory, and that difficulty, though an almost necessary accompaniment of any such theory, would be alone sufficient to prevent one from urging its acceptance on dynamical grounds alone. It does not appear that, for such enormous periods of time as we are here concerned with, our ordinary dynamical equations are of sufficient exactitude to prevent the entrance of some unknown factors, which may profoundly modify the course of the evolution of the system. This difficulty must be regarded as an additional cause for receiving the theory with all reserve. . . .

The present small obliquity of Jupiter, requiring an almost impossibly great viscosity if explained by solar tidal friction alone, had been regarded as a natural consequence of the tidal action of the satellites. And the large angle through which Saturn* had tilted since the evolution of Phoebe had been looked upon as in great part due to the tidal action of its satellites.

We may say, then, that the theory of planetary inversion suggests, but does not absolutely require as a condition for its truth, an annular stage in the history of the satellites of Jupiter and Saturn. More than this we do not care to state till a more detailed application of the tidal theory has been made to the case of a planet attended by a group of satellites. The very doubtful question whether perturbations in a ring of satellites

*Jupiter's VIIIth satellite had not been discovered when Mr. Stratton's paper was written.

could ultimately lead to the formation of one or several satellites must also be discussed before the difficulties considered in this section can be removed."

Again, in the summary of his results, on pages 400-401, Mr. Stratton continues: "Jupiter must have evolved its satellites after its obliquity had decreased below 90°; partly under their influence it has been driven down towards a stable position of small obliquity, which it has now nearly reached. Saturn shed Phoebe, and possibly also Japetus and Hyperion, while its obliquity was greater than 90°; as under solar tidal influence it passed through the critical position, where its obliquity was 90°, Phoebe sank down into the ecliptic in a retrograde orbit, while Japetus and Hyperion moved over with the planet's equator. Afterwards the inner satellites were evolved, and under their influence and the influence of the rings Saturn's obliquity has steadily diminished—and is still diminishing—towards a small stable value. As seems highly probable for a planet farther removed from the Sun, and therefore less likely to have its increasing rotation checked by solar tidal friction, the satellites of Uranus were evolved in an earlier stage of its evolution, before its obliquity had decreased to 90°; they have stopped the decrease in obliquity, which would arise from the solar action, and they are now driving Uranus back to a stable position with an obliquity of 180°. Neptune, with its one satellite of extremely large tidal influence, is being driven towards an equilibrium position with an obliquity of 180°. I should add that uncertainty as to the data for the satellites of Uranus and Neptune leaves even the present direction of motion of their equators very doubtful, but that the results above given seem on the whole the most probable.

I suggest as the easiest explanation of certain remaining difficulties that the satellites of Jupiter and Saturn have passed through an annular form at some previous stage in their history. This latter idea is not essential to the successful working out of the theory; at present it is only put forward very tentatively indeed, and as a subject for further research.

Viewed broadly, then, the theory of planetary inversion, though it entails some difficulties of detail, remains a tenable hypothesis. As explained by Sir George Darwin's tidal theory it involves three main assumptions: (1) that the outer satellites of a planet were evolved before the inner ones; (2) that the determining factor producing secular alterations in a planet's obliquity has been tidal friction; and (3) that the time

involved in the scheme is not so great as to invalidate the ordinary dynamical equations. A justification for these assumptions may perhaps lie in the satisfactory explanation which the theory affords both of the large obliquities of Uranus and Neptune and of the presence of a satellite such as Phoebe. The secular motions with which the theory is concerned are so extremely slow that it can hardly yet be proved or disproved by reference to the gravitational theory of the motions of planets and their satellites; the theory would gain some support by the discovery of satellites to Uranus and Neptune of the same type as Phoebe, if their motion were retrograde; it would be overthrown if their motion were direct. The theory remains then at present a speculative hypothesis, which is on the whole well supported by the theory of tidal friction, and which gives the only explanation so far offered for certain facts."

It is impossible to convey the contents of this lengthy and well prepared paper, even by quotations of such considerable length as are here given; but this seemed the only way of doing the author even moderate justice, because of the difficulty of condensing the results into smaller compass, without omitting some important considerations. The chief significance of Mr. Stratton's investigation lies in the continued adherence to Laplacian traditions, in spite of the negative and therefore unsatisfactory criticisms of Moulton and Chamberlin; and in the avoidance of any suggestion that the observed satellites might have been captured, though Sir George Darwin, under whose inspiration Mr. Stratton's work was done, had eight years before published his celebrated memoir on Periodic Orbits (Acta Mathematica, vol. 21), and during the previous year had given valuable suggestions on cosmical evolution in his presidential address to the British Association at Cape Town, 1905. One cannot but wonder to what extent Moulton's misleading criticism of Professor W. H. Pickering's suggestion of the possible origin of Phoebe by capture (*Astrophysical Journal*, vol. 22, pp. 177-180), with the accompanying fatal misinterpretation of Jacobi's integral, may have been responsible for the rejection of the only idea which could simplify our theory of the observed satellites, and bring it into harmony with the purely mathematical results arrived at by Professor Sir G. H. Darwin in his justly celebrated memoir on Periodic Orbits.

To be continued.

AN ASTRONOMICAL THEORY OF THE MOLECULE AND AN ELECTRONIC THEORY OF MATTER

Solar and Terrestrial Physics Viewed in the Light Thereof.

SEVERINUS J. CORRIGAN

For Popular Astronomy.

Part IV. (Continued.)

The Terrestrial Atmosphere. Its Volume, Extent, Density, Pressure, Temperature and the Meteorological Effects caused therein by the Solar Electro-Magnetic Radiations.

It may be remarked that a portion of the heat so generated in the pulverized matter must be lost by conduction through the surrounding cooler strata on all sides, and so it is, but as the thermal conductivity of underground strata is experimentally known to be very low, and the heat is generated almost instantaneously, and, furthermore, as earthquake movements often continue for many times the aforesaid period of twenty seconds, the temperature may be raised, and remain, above the melting points and even above the points of evaporation of all, even the most refractory, matter affected by the movement, for a considerable period even if a great loss by conduction be allowed. Moreover, so abundant is the heat generated, that there may be a stratum of molten, and even vaporized, matter —or more likely a mixture of matter in both states—having a thickness of not only one foot but of many feet, indefinitely extended around the seismic focus, throughout the whole area in which there is an actual movement of the particles of the strata at the aforesaid depth.

From what has been stated just above, it is apparent that, under my theory in this connection, the intrinsic, internal temperature of the Earth, great as it is at a considerable depth, is not an active factor in the causation of earthquakes and volcanic eruptions and the production of the highly heated matter ejected therein, the latter being a result of the former, earthquakes being caused by the stress exerted by abnormal atmospheric, or other, pressure, upon regions wherein there are areas

of weakness, or "faults," in the geologic formations, and that all these seismic effects would take place even were the whole mass of matter composing our globe *absolutely cold,* the heat that is made manifest in volcanic phenomena being simply the result of mechanical action due to the movement of great masses of rocky strata comparatively near the Earth's surface, when rupture and displacement occur therein and send through the otherwise unaffected strata of the Earth those vibrations of elastic compression and expansion that constitute the earthquake waves that, in some cases, are transmitted to all parts of our globe from the seismic focus wherever it may be, as is indicated by the records of the delicate seismographs now in use. These deductions from my theory indicate that at, or about, the aforesaid mean depth of the seismic focus, throughout quite extensive areas in regions subject to earthquakes of considerable violence, there exist layers of intensely hot, gaseous, liquid, and viscous matter interposed between the cold, solid superficial strata and the extremely rigid mass of the Earth at greater depths. The heat of this matter may cause the observed rate of temperature increase downward (one degree per fifty-five feet which is the mean derived from many observations, and also the mean derived through my theory by means of the rate of radiation from the Earth's surface into space) and the known thermal conductivity of the underground strata to be considerably greater than that due to the intrinsic, maximum temperature which is 6,340 degrees Fahrenheit at a depth of sixty-six miles, although deviations from the mean rate may be accounted for, at least in some cases, by the underground strata having different thermal conductivity—increase of conductivity and *vice versa.* It is well-known that in many regions scattered over the globe this rate is so great that a high temperature is reached not far below the surface, as indicated by hot springs, wells and geysers, and the existence of a stratum of hot, viscous matter interposed between the cool outer strata and the solid core beneath, this stratum completely enveloping the latter, is an hypothesis advanced years ago, and one that has still many advocates, but certain principles of dynamics, involved in the process of tidal action caused by the Sun and the Moon (particularly by the latter body) render this hypothesis scientifically untenable; but against the hypothesis that I have advanced just above and which asserts that there exist in divers scattered and restricted regions of our globe, at depths of only

a few miles beneath the surface, comparatively thin strata of extremely hot matter, not only viscous and liquid, but even gaseous, forming as it were lakes or pools of composite fluid, there can be brought, so far as I have been able to determine, no valid scientific argument, or objection; in fact, unless well-known laws of mechanics and thermotics may be nullified, such collections of fluid matter must be found and exist if there be any considerable displacement and movement of great masses of the rocky strata extending not far below the Earth's surface, such as is known to occur in, and to be the immediate cause of earthquakes.

The chemical reactions necessarily resulting from the extremely high temperature of this matter, which temperature, as I have demonstrated theoretically, may be higher than that required to vaporize the most refractory known substance, *carbon,* and therefore every known constituent of the Earth, and the mechanical effects consequent upon these reactions are most important factors in the processes of volcanic action as will be demonstrated. It is known that even the most solid rocks occlude, or contain within themselves, considerable although invisible quantities of water and that surface water such as those of the ocean may infiltrate, or percolate, to great depths and under the conditions of the extremely high underground temperature aforesaid this water must be decomposed into its component gases, hydrogen and oxygen, and not merely into steam as would be the case at a much lower temperature of the internal heated stratum aforesaid the latter view being one quite generally held by physicists.

The heat generated by the movements of the underground rocky strata on or about, a level with the seismic focus, during an earthquake, may easily be so great it will more than suffice to vaporize the most refractory solids, such as silica and the silicates which are the principal constituents of the solid superficial matter of our globe, and even the solid primitive carbon which, for reasons that I have stated in a preceding part of this paper, is, in all probability, an abundant (if not the chief) constituent at very considerable depths where it has not been exposed to, and turned into carbon dioxide gas (in some cases to the monoxide) by chemical combination with oxygen so abundant not only freely in the atmosphere, but to some distance beneath the Earth's surface, principally in chemical combination with the element silicon (a congener of carbon) this combination forming the solid silica of which quartz, pure sand and

other earthly matter are types, and with aluminum, calcium, magnesium and other solid elements of which clays, limestones and other rocks are composed.

Furthermore, it is very obvious that the vaporization of this matter confined in the depths below the Earth's surface, must generate an enormous pressure that will force the heated fluid and viscous matter to move along lines of least resistance, either horizontally or at any angle of inclination, for long distances and from considerable depths, until it reaches a point where it can rise nearly vertically to, and escape above, the surface of the Earth.

These lines, or tubes, of least resistance form the ducts and vents leading upward to the crater, or mouth, of a volcano, in the lower part whereof all this vaporized matter cools below the critical temperature of dissociation of its atoms and molecules so that chemical re-combination becomes possible, the chemical union of the hydrogen and oxygen forming steam; that of carbon and oxygen resulting in the formation of carbon monoxide gas and finally of carbon dioxide, or carbonic acid gas. To the sudden combination of these, and other, previously dissociated elements in the depths of the crater where they are more or less confined by the molten matter above, or in some cases by solid obstructions, are attributable the thunderous explosions and violent earthshakings (not *earthquakes* proper) that are often accompaniments of great volcanic eruptions such as those of Vesuvius, Aetna, Pelée and other volcanic mountain peaks. The mass of vapor that burst from the side of Mount Pelée considerably below the top of the crater thereof, and which fell upon, and destroyed, the city of St. Pierre, Martinique, during the memorable eruption in May, 1902, and like phenomena in the case of Vesuvius and many other volcanoes in divers parts of the world, consisted, in all probability, either wholly, or in part, of either pure carbon vapor, or of carbon monoxide, flaming with explosive suddenness and violence into carbon dioxide upon contact with the oxygen of the outer air.

Silica and other solid rocky matter which was first finely pulverized by earthquake movements at, or about, the depth of the seismic focus, and highly heated, or even vaporized, by friction and compression due to these movements, subsequently cooled to the molten, or viscous, state, and in some cases after being made light, or spongy, by the commixture therewith of steam and gases, is finally ejected from the crater as lava, pumice and other products of a volcano. Therefore, while it

has been scientifically demonstrated that the Earth as a whole, is a very solid, rigid body although the internal matter thereof, at depths below sixty-six miles, or so, is most highly heated by reason of the compression of the primitive, greatly expanded gaseous nebula, which has condensed to the present dimensions and solid condition of our globe, there must exist, here and there, in divers regions of the Earth, and not very far beneath its surface, accumulations, or pools, of highly heated fluid and viscous matter under enormous gaseous pressure, the heat whereof results, not from the aforesaid intense intrinsic heat at very great depths, but from the friction and compression caused by earthquake movements of enormous masses of rocky strata comparatively cool and near the surface, and which heat would result were the whole internal mass of the Earth *cold* even to a close approximation to what is called the "absolute zero" of temperature, which is nearly 460 degrees below the zero of the Fahrenheit scale. The contraction of our globe due to the extremely slow "secular cooling" of its internal matter is, at the present time, only an insignificant factor in the causation of seismic disturbances and volcanic action resulting therefrom.

Under this hypothesis it is evident that in such pools of gaseous, liquid and viscous matter there exist all the elements necessary to the chemical generation (under varying degrees of temperature) of all the hydrocarbon gases and oils that, in divers ways, reach the Earth's surface and this matter may be in process of production so long as sufficient heat is generated by seismic movements of the superficial rocky strata of the Earth in the manner aforesaid.

It is also obvious that a withdrawal of any portion of this matter, by its ejection from the craters of volcanoes, or otherwise, must leave more, or less, vacuous spaces (which, in themselves, constitute areas of weakness, conducive to further seismic disturbances) and that a giving way and sinking of the overlying strata must occur, the extent whereof corresponding somewhat with the quantity of matter ejected at the surface much of which goes to the upbuilding of volcanic cones subsequently, in many cases, rounded out by erosion and denudation, after the volcano becomes, as it is called (often *deceptively,* as in the case of Mount Pelée and others), "extinct." Such action, in nearly continuous operation, throughout long periods of time, would account well for the subsidence of some parts of the Earth's surface, and for the elevation of others, that has taken place in the past, and is known to be still in progress to some—and

often considerable—extent. There are decided indications that in the early geological ages the surface of the Earth was, in general, more nearly level than it now is, and that it was quite completely covered by the waters of the ocean the depth whereof was less, and more nearly uniform, than it is at the present. Long subsequently, at the time when, in the words of Genesis, "the waters were gathered togeher and the dry land appeared," the subsidence of the strata caused, in part, by the slow secular cooling of the internal matter of our globe, and, probably, in greater part, by the seismic action described on preceding pages, resulted in depressions in the ocean bed and the elevation of the continents and islands, thereby giving to said ocean beds and the elevated lands their present configurations. It is a notable and important fact, in this connection, that the greatest ocean depth that has been sounded, and the altitude of the highest mountain peak that has been measured, are about equal, both being between five and six miles.

Therefore, under my theory in this connection, volcanic action is quite directly traceable—through the intervening medium of earthquake movements—to meterological disturbances, earthquakes being caused, in the majority of cases, by the giving way of underground strata under stress caused by abnormally high and persistent atmospheric pressure over certain regions beneath which there are areas of weakness in said strata. But high barometric pressure is, obviously, a complement to, or an inevitable result of, low barometric pressure because, since the whole mass of atmospheric air enveloping our globe is, practically, constant in quantity, the accumulation of a surplus over any one region must be at the expense of a deficiency over another contiguous region, the warm, moist—and therefore lighter—air in an area of low, barometer storm center, or true cyclone, rising upward and flowing over on all sides, then becoming cooler, heavier and in its descent producing an area of high barometric pressure, or an anti-cyclone, from the center of which the air flows downward, outward, and in toward the center of low barometric pressure, or true cyclone aforesaid, the whole process being one of simple "gaseous convection" operating under the well-known principles and laws governing the flow of fluids, or gases, such as air, differing in density, pressure and temperature. Therefore, under my theory in this connection, a *nexus* is established between seismic and volcanic action and solar radiation, because the formation of an area of low barometric pressure, and its complement, one of

high atmospheric pressure, or the anti-cyclone which is the principal factor in the causation of seismic disturbances, are due quite directly, to the electromagnetic radiations emitted from the surface of the Sun, these radiations being transformed into heat vibrations, in large part, by their passage through the Earth's atmosphere the destiny whereof increases downward from the density of the gaseous, luminiferous ether by and through which they have been transmitted through the space between the Sun and the Earth.

It should be noted that while my theory asserts that the aforesaid abnormally high atmospheric pressure is the chief cause of seismic disturbances, it does not claim that this is the only possible one, since any disturbance that will put an abnormal stress upon unstable, or weakened, underground strata, may result in the giving way of portions thereof, with consequent earthquake shocks. For instance, the mechanical action of ocean waves resulting from great storms, and beating upon coasts in regions known to be subject to seismic disturbances, may cause such disturbance; but it is obvious that this action is, itself, simply a consequence of meteorological, or atmospheric conditions, in regard to differences of atmospheric pressure. Another possible cause of earthquakes, and one that some seismologists and other physicists are inclined to regard as the principal one, is the distorting stress put upon the Earth by the tidal force of the Sun and the Moon, and particularly of the latter body the relative effect whereof may be two to one.

My investigation of this subject which has led me to the conclusion that the principal cause is the high atmospheric pressure aforesaid, has also indicated that in a few cases the Moon when near its syzygies, seems to have had some such effect, but this was in connection with, and simply auxiliary to, the atmospheric cause.

Although, in some cases, this tidal action alone may bring about seismic disturbances, it is quite evident that is only a subsidiary cause and not the principal one, for if it were the movements and positions of the Moon and the Sun are so well-known, for any future time, that we might predict, almost exactly, the probable dates of seismic disturbances the period whereof would be short, and quite regular, corresponding to the monthly motion of the Moon and to the times of the "spring tides"; in fact, were this the principal cause of seismic disturbances it would be quite possible to construct what might be called an "earthquake ephemeris." But while my investigation

indicates a periodicity in the occurrence of earthquakes, the period is neither a monthly nor annual one, but approximates, roughly though it be, the eleven-year sun-spot period, a fact that is quite clearly explicable under my hypothesis that they are attributable to the atmospheric conditions aforesaid, for it is well-known that the curves of frequency of meteorological disturbances and of auroral and magnetic maxima and minima, coincide quite closely with that of the sun-spots, a fact that indicates a correlation between all these phenomena, and a common cause thereof. But, even when atmospheric conditions as to pressure are clearly indicative of the possibility of the occurrence of an earthquake, none will result unless the underground rocky strata be in a condition of unstable equilibrium, or weakness, such that portions thereof will give way under the stress due to the abnormal pressure aforesaid, and it is, therefore, evident that this factor, and possibly others unknown, mask somewhat the real connection between meteorological and seismic disturbances.

Furthermore, basing their claims upon the luni-solar tidal action aforesaid, some investigations hold that the planets of the solar system—particularly the larger ones—throw a similar tidal stress upon our globe, which results in periodic seismic disturbances therein, the period depending upon the relative positions of the planets with respect to the Earth, but since the masses of all the planets are comparatively small and their distances from the Earth very great, and since the tidal action varies inversely as the cube of this distance, the well-known dynamical laws governing in this case preclude the possibility of planetary tidal action upon the Earth sufficiently strong to cause seismic movements; but under my theory that the principal cause is to be found in the meteorological conditions aforesaid, the existence of planetary influence on the Earth, sufficiently great to cause such disturbances, becomes demonstrable for the following reasons.

In a preceding part of this paper, I have stated the fundamental proposition that a heated body, such as the Sun, cannot radiate any of its heat, and cool, unless there be in surrounding, space other bodies, or matter, at a lower temperature to receive, or absorb the thermal radiations from the more highly heated body, and, in the case of the solar system, it is evident that the principal absorbing, or receiving, bodies are the planets, and that the far distant stars cannot be such absorbers, because the temperatures of their own radiating surfaces are as high as (if not higher, in many cases, than) that of the Sun.

St. Paul, Minn. To be continued.

ASTRONOMICAL PHENOMENA IN 1910.

ECLIPSES.

There will be four eclipses during the year 1910, two of the Sun and two of the Moon. The following data are taken from the *American Ephemeris:*

(1) *A Total Eclipse of the Sun,* 1910, May 8th, invisible at Washington.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of ☍ in right ascension, May $8^d\ 17^h\ 3^m\ 22^s.5$

	h	m	s		s	s
Sun's and Moon's R. A.	3	0	53.90	Hourly motions	9.71	and 147.52
Sun's declination	17°	6′	59″.6 N	Hourly motion		0′ 47″.7 N
Moon's declination	16	4	48 .7 N	Hourly motion		13 56 .3 N
Sun's equa. hor. parallax			8 .7	Sun's true semidiam		15 50 .4
Moon's equa. hor. parallax	61	17	.9	Moon's true semidiam.		16 41 .4

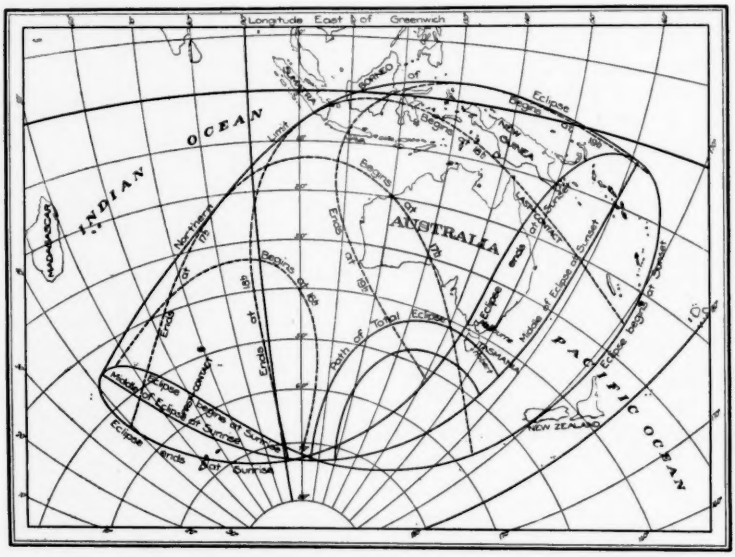


CHART OF THE SOLAR ECLIPSE MAY 8, 1910

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time.			Longitude from Greenwich.		Latitude.	
	d	m	h	°	′	° ′	
Eclipse begins	May 8	15	38.4	61	33.7 E	55	56.4 S
Central eclipse begins	8	17	9.3	112	1.5 E	72	37.1 S
Central eclipse at noon	—	—	—	—	—	—	—
Central eclipse ends	8	18	15.6	156	12.6 E	46	31.2 S
Eclipse ends	8	19	46.4	147	33.2 E	15	36.0 S

(2) *A Total Eclipse of the Moon*, 1910, May 23, visible at Washington; the beginning visible generally in the central and western portions of Africa, southwest Europe, South America, North America excepting Alaska, and the southern Pacific Ocean; the ending visible generally in South America, North America excepting Alaska, and the central and southern Pacific Ocean.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of ☍ in right ascension, May $23^d\ 17^h\ 48^m\ 53^s.2$.

	h	m	s		s
Sun's right ascension	4	0	20.72	Hourly motion	10.06
Moon's right ascension	16	0	20.72	Hourly motion	122.93
Sun's declination ..	20°	36′	26″.9 N	Hourly motion	0′ 28″.6 N
Moon's declination	20	59	4 .2 S	Hourly motion	8 37 .3 S
Sun's equa. hor. parallax			8 .7	Sun's true semidiam.	15 47 .5
Moon's equa. hor. parallax	54	17	.4	Moon's true semidiam.	14 46 .9

CIRCUMSTANCES OF THE ECLIPSE.

	d	h	m	
Moon enters penumbra	May 23	14	32.5	Greenwich Mean Time
Moon enters shadow	23	15	46.4	
Total eclipse begins	23	17	9.0	
Middle of the eclipse	23	17	34.3	
Total eclipse ends	23	17	59.6	
Moon leaves shadow	23	19	22.3	
Moon leaves penumbra	23	20	36.2	

Contacts of shadow with Moon's limb.	Angles of position from the north point.	The Moon being in the zenith in longitude from Greenwich,	and in latitue.
	°	° ′	° ′
First	84 to E	58 26 W	20 41 S
Last	49 to W	110 42 W	21 12 S

Magnitude of the eclipse = 1.099 (Moon's diameter = 1.0).

(3) *A Partial Eclipse of the Sun*, 1910, November 1, invisible at Washington.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of ☍ in right ascension, November $1^d\ 13^h\ 11^m\ 35^s.1$.

	h	m	s		s	s
Sun's and Moon's R. A.	14	25	25.58	Hourly motions	9.80 and	111.78
Sun's declination	14	25′	21″.1 S	Hourly motion		0′ 48″.2 S
Moon's declination	13	22	36 .3 S	Hourly motion		12 2 .5 S
Sun's equa. hor. parallax			8 .9	Sun's true semidiam.		16 7 .2
Moon's equa. hor. parallax	54		4 .3	Moon's true semidiam.		14 43 .4

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time			Longitude from Greenwich		Latitude.	
	d	h	m	°	′	°	′
Eclipse begins	November 1	11	51.1	118	30.2 E	63	3.5 N
Greatest eclipse	1	14	8.6	155	14.0 W	62	2.0 N
Eclipse ends	1	16	26.4	165	23.2 W	17	35.3 N

Magnitude of great eclipse = 0.852 (Sun's diameter = 1.0).

(4) *A Total Eclipse of the Moon*, 1910, November 16, visible at Washington; the beginning generally in Africa, Europe, central and western Asia, South America and eastern North America; the ending visible generally in Africa, Europe, western Asia, North and South America.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of ☍ in right ascension, November $16^d\ 12^h\ 36^m\ 11^s.1$.

	h	m	s		s
Sun's right ascension	15	25	38.35	Hourly motion	10.31
Moon's right ascension	3	25	38.35	Hourly motion	152.72
Sun's declination	18°	43′	52″.7 S	Hourly motion	0′ 37″.5 S
Moon's declination	19	10	37 .0 N	Hourly motion	12 52 .8 N
Sun's equa. hor. parallax			8 .9	Sun's true semidiam.	16 10 .8
Moon's equa. hor. parallax	61	28	.3	Moon's true semidiam.	16 44 .2

CIRCUMSTANCES OF THE ECLIPSE.

		d	h	m	
Moon enters penumbra	November	16	9	45.6	Greenwich Mean Time
Moon enters shadow		16	10	44.0	
Total eclipse begins		16	11	54.9	
Middle of the eclipse		16	12	20.8	
Total eclipse ends		16	12	46.8	
Moon leaves shadow		16	13	57.7	
Moon leaves penumbra		16	14	56.1	

Contacts of shadow with Moon's limb.	Angles of position from the north point.	The Moon being in the zenith in longitude from Greenwich,	and in latitude.
	°	° ′	° ′
First	93 to E	14 6 E	19 46 N
Last	134 to W	32 23 W	19 28 N

Magnitude of the eclipse = 1.131 (Moon's diameter = 1.0).

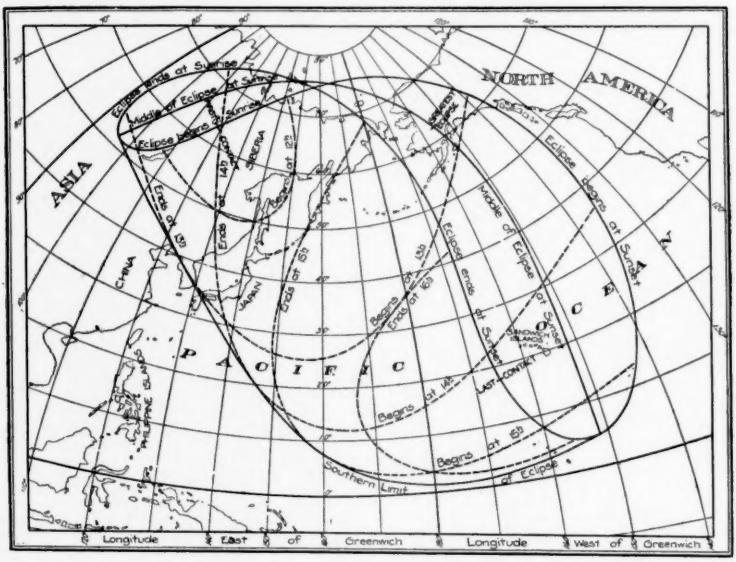


CHART OF THE SOLAR ECLIPSE NOVEMBER 1, 1910.

The regions within which the eclipse of the Sun are visible are laid down on the accompanying charts, from which, by means of the dotted lines, the Greenwich mean time of beginning and ending at any place may be found with an uncertainty which will vary from three to four minutes for a high Sun to fifteen or twenty minutes when the Sun is near the horizon.

THE PLANETS.

The apparent courses of the planets among the stars for the year 1910 are shown upon the charts Figures 1 and 2.

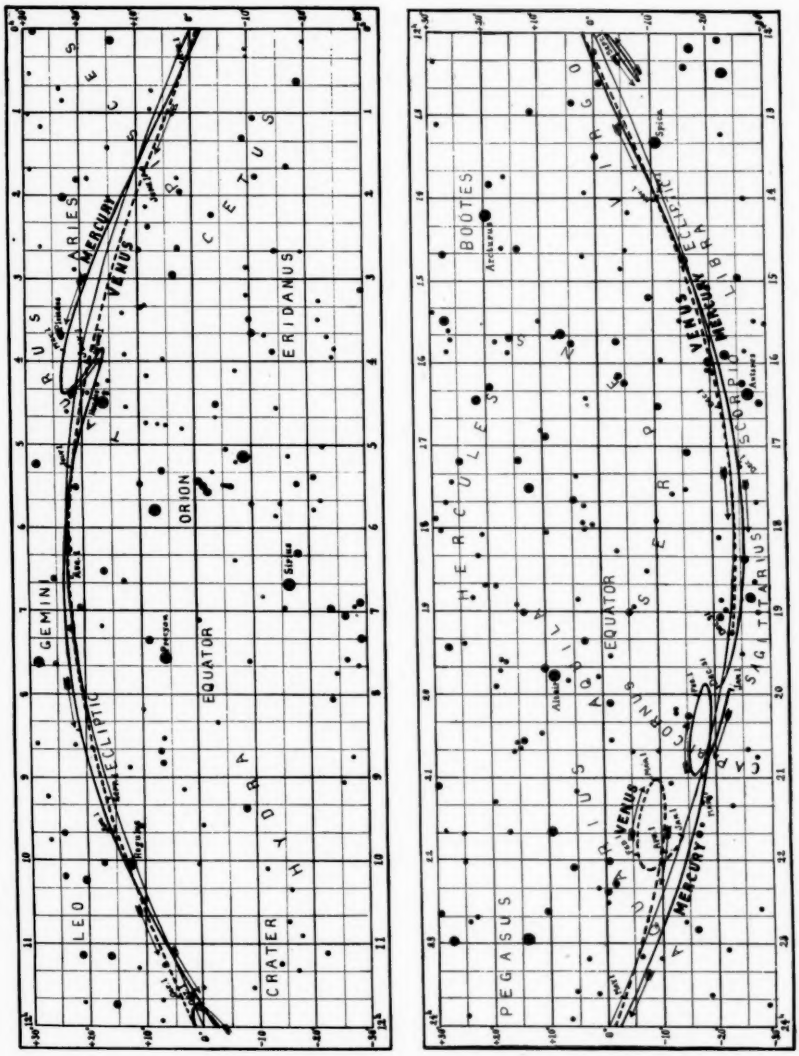


FIGURE 1. APPARENT PATHS OF MERCURY AND VENUS AMONG THE STARS DURING 1910.

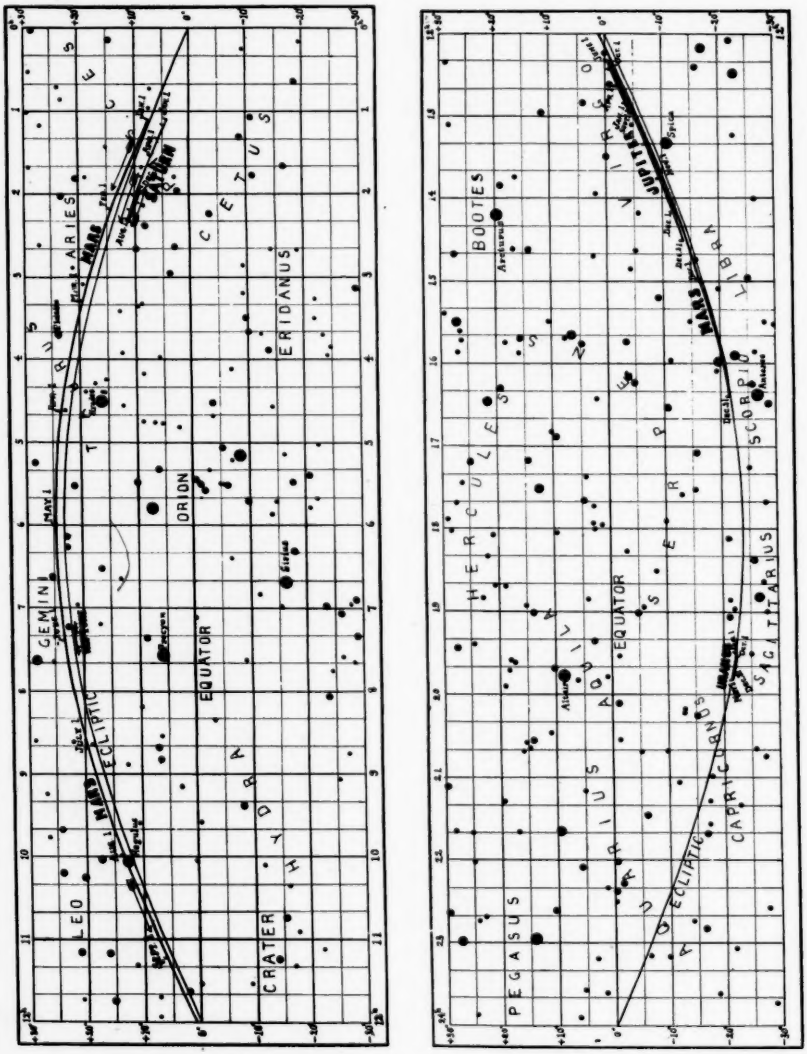


FIGURE 2. APPARENT PATHS OF MARS, JUPITER, SATURN, URANUS AND NEPTUNE AMONG THE STARS DURING 1910.

Mercury begins the year between Sagittarius and Capricorn and during the first two months describes a great closed loop, as it passes between the Earth and the Sun. In May and June it describes an S-shaped loop in Taurus and again in September forms a closed loop in Virgo. Comparing these loops with those in the path of Mercury for last year one will see that they are much the same in form, but are shifted westward about 30°. At the end of the year Mercury will be just beginning to make the turn on another loop like that made at the beginning of the year. The following are the times when Mercury will be in conjunction with the Sun:

Inferior conjunction			Superior conjunction		
Central Standard Time					
Jan.	25	15h	April	5	5h
May	24	23	July	18	22
Sept.	25	14	Nov.	11	20

The planet is best seen when at greatest elongation east and west from the Sun, but not equally well at all of these occasions. Its brightness varies greatly because of the different circumstances of its illumination by the Sun, its altitude above the horizon and the depth of twilight or dawn in which it must be viewed. From the following table of greatest elongations it will appear that the best opportunities to see the planet will be in January, October and December.

Greatest Elongations of Mercury.

			Angle from Sun	Brightness
Jan.	9	18h	East 19° 03′	62
Feb.	19	10	West 26 33	39
May	1	22	East 20 55	44
June	19	8	West 22 48	35
Aug.	30	5	East 27 14	32
Oct.	11	3	West 18 03	65
Dec.	24	0	East 19 54	58

Venus starts out upon a great closed loop in Aquarius at the beginning of the year, taking about three months to complete it, and then continues forward movement along the ecliptic during the remainder of the year, ending its course in Sagittarius. Venus will be at greatest brilliancy January 7, before passing the Sun February 12 and again on March 18.

Mars' course starts in Pisces near Saturn and continues eastward along the ecliptic during the entire year, ending in Scropio. Mars will pass Neptune in May and Jupiter in November.

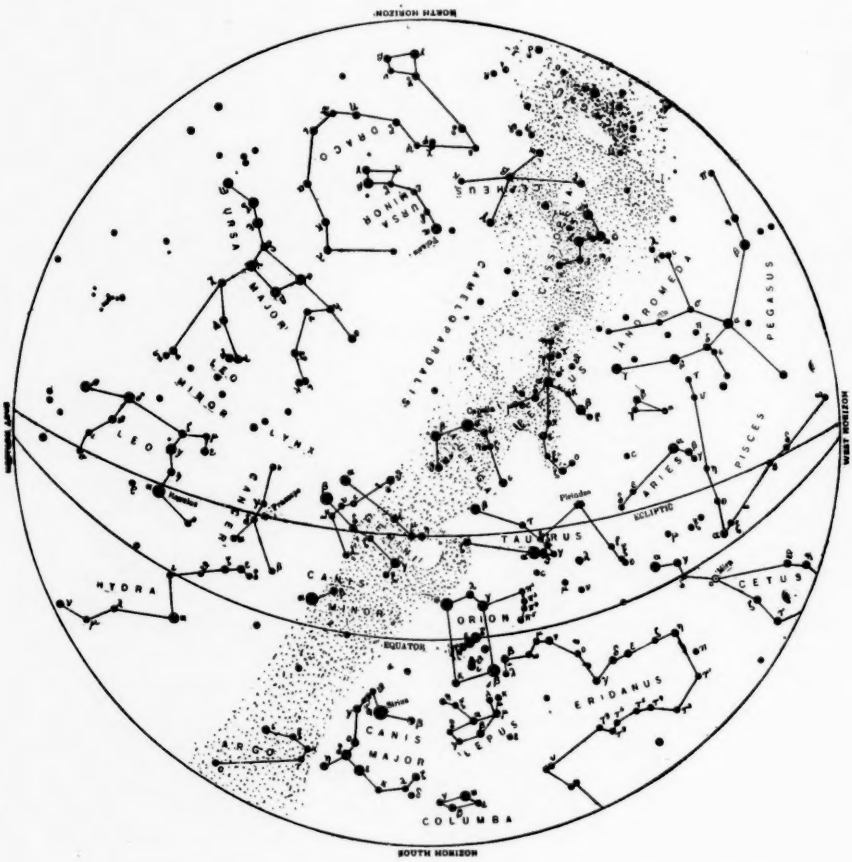
Jupiter's course is through Vigo into Libra, the movement being direct during January, then retrograde until June 2, and after that direct for the rest of the year. Jupiter will be at opposition March 30, and so will be in position for observation during the winter and spring months.

Saturn's path lies through Pisces and Aries, the motion being direct until August 20 and retrograde during the remainder of this year. Saturn will be at opposition October 26, and therefore will be in position for observation during the autumn and winter. The rings will be quite well open to view this year,

the Earth being 18° below the plane of the rings in August, and 16° below in December.

Uranus describes a short course in Sagittarius, moving eastward until May 1, then westward until October 1 and eastward again for the rest of the year.

Neptune's path is a short one in Gemini, the movement being retrograde until the latter part of March, then direct utnil October 25 and after that retrograde.



THE CONSTELLATIONS AT 9:00 P. M., FEBRUARY 1, 1910.

PHASES OF THE MOON.

1910 Washington Mean Time.

	New Moon.			First Quarter.			Full Moon.			Last Quarter.		
	d	h	m	d	h	m	d	h	m	d	h	m
										Jan. 2	20	18.5
Jan.	10	18	42.9	Jan. 17	17	12.3	Jan. 24	18	42.3	Feb. 1	18	18.8
Feb.	9	8	04.7	Feb. 16	1	24.2	Feb. 23	10	27.5	Mar. 3	14	43.9
Mar.	10	19	04.1	Mar. 17	10	29.0	Mar. 25	3	12.4	Apr. 2	7	39.3
Apr.	9	4	16.8	Apr. 15	20	55.7	Apr. 23	20	14.4	May 1	20	21.3
May	8	12	24.6	May 15	9	04.8	May 23	12	30.8	May 31	5	16.2
June	6	20	08.1	June 13	23	11.1	June 22	3	03.6	June 29	11	30.6
July	6	4	11.7	July 13	15	16.1	July 21	15	28.7	July 28	16	26.2
Aug.	4	13	28.5	Aug. 12	8	52.8	Aug. 20	2	05.8	Aug. 26	21	24.9
Sept.	3	0	57.4	Sept. 11	3	02.3	Sept. 18	11	44.0	Sept. 25	3	45.4
Oct.	2	15	23.7	Oct. 10	20	31.7	Oct. 17	21	16.1	Oct. 24	12	39.6
Nov.	1	8	47.8	Nov. 9	12	21.1	Nov. 16	7	16.7	Nov. 23	1	05.1
Dec.	1	4	02.4	Dec. 9	1	57.1	Dec. 15	17	56.8	Dec. 22	17	27.3
Dec.	30	23	12.9									

OCCULTATIONS VISIBLE AT WASHINGTON.

Date 1910	Star's Name	Magnitude.	IMMERSION. Washington M.T. h	m	Angle f'm N. °	EMERSION. Washington M.T. h	m	Angle f'm N. °	Duration. h	m
Feb. 12	54 B. Citi	6.3	8	27	40	9	16	266	0	49
15	145 B. Arietis	6.5	8	43	22	9	31	295	0	48
19	40 Geminorum	6.3	8	7	34	8	55	327	0	48
19	52 Geminorum	6.1	15	58	147	16	33	234	0	35
23	46 Leonis	5.8	5	34	141	6	21	251	0	47
26	46 Virginis	6.1	15	36	195	16	12	243	0	36
26	48 Virginis	6.5	17	31	120	18	45	304	1	14

COMETS.

The new comet discovered by Daniel at Princeton, December 6, will continue to be visible for some months. Perrine's periodic comet 1896 VII, which was picked up by Wolf in August and passed perihelion October 31, may also be visible for sometime yet.

No less than seven periodic comets may be looked for during 1910.

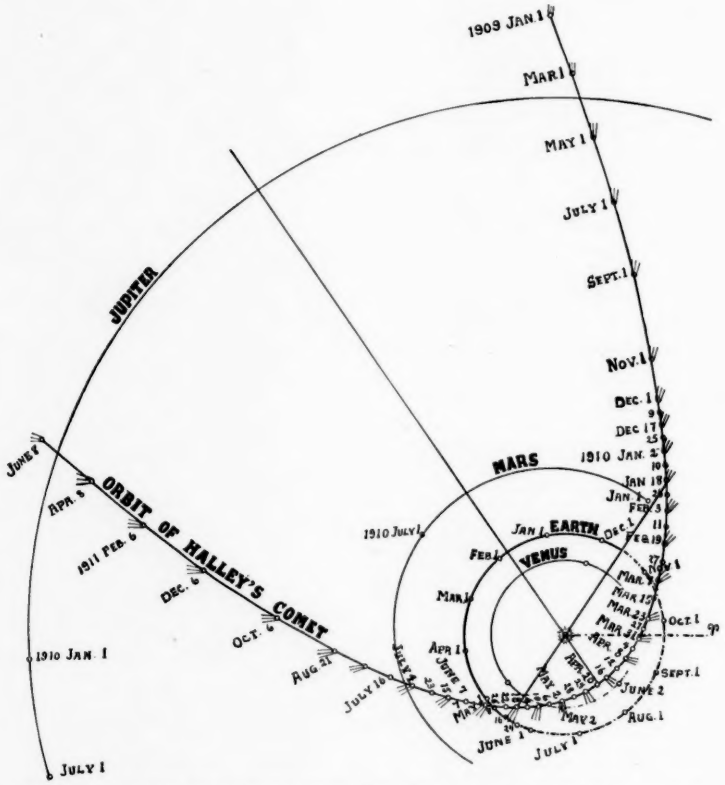
1. *Giacobini's* comet 1896 V, which was expected to reach perihelion about the middle of February, 1910, has been shown by later computations to be due during December, 1909, but has not yet been detected. Its position is unfavorable so that its detection may be doubtful.

2. *Swift's* comet 1895 II was not seen at its return in 1902 and, unless its orbit has been considerably changed the conditions will be much less favorable for its discovery this year. It is due at perihelion about the end of January when it will be almost behind the Sun.

3. *Tempel's* second periodic comet is due at perihelion about February 21, unless its orbit has been materially changed by the perturbation of the planets since 1904 when it was last seen. Its position this year is extremely unfavorable being almost directly behind the Sun at the time of perihelion passage.

4. *Halley's* great comet has already been sighted, and is brightening rapidly. It will not reach perihelion until April 20 and will not reach its point of nearest approach to the Earth until May 18, when its seems likely to pass directly between the Earth and the Sun. For a few weeks both before and after that date astronomers anticipate that the comet will be visible to the naked eye, and that for a few days at least it may be a magnificent object.

The accompanying diagram prepared by Mr. C. H. Gingrich shows the relative positions of the comet and the planes while the comet is in the vicinity of the Sun.



Positions of Halley's Comet with Reference to the Planets in 1909-10.

5. *D'Arrest's* comet was last seen in 1897, the return in 1904 being under conditions unfavorable to its detection. This year unless its orbit has been materially changed, it will be at perihelion early in October, and the conditions are favorable to its discovery during the summer.

6. *Spitaler's* comet 1890 VII was not seen at its returns in 1897 and 1903, because of its unfavorable position. In a recent number of the *Astronomische Nachrichten* (*A. N.* 4371) Dr. E. Hopfer, of Triest, gives revised elements of the orbit, taking into account the perturbations by Jupiter from 1890 to 1903, and shows that the orbit has been quite materially changed. The resulting period, according to the elements for 1903, is 6.82 instead of 6.42 years, which if there is no further serious change will bring the next perihelion passage early in October of this year. In that case the conditions will be fairly favorable to its rediscovery.

7. *Faye's* well-known periodic comet is due again in the latter part of October under favorable circumstances.

8. *Brooks'* comet 1889 V is not due at perihelion until about the middle of January, 1911, but is more likely to be seen during the summer of 1910 than at the time of its perihelion.

VARIABLE STARS.

The list of the Algol type stars whose periods are fairly well determined numbers now seventy, with several more suspected or having poorly determined periods. Ephemerides of the minima of all of these except where the period is less than half a day have been computed for 1910, and will be given in POPULAR ASTRONOMY as in former years.

For the stars of short period not of the Algol type the times of maxima have been calculated except where the period is less than one day. The number in this class of variables now on our list is 87.

We are endeavoring to keep our list of elements up to date and expect soon to publish a revised list of elements similar to that given in POPULAR ASTRONOMY, vol. XIV, p. 75. We shall be glad of any suggestions from variable star observers as to improvement of the form of the list and especially to receive corrections and recent revisions of elements which have or have not yet been published.

METEOR SHOWERS.

The following list of the more brilliant meteor showers in Mr. Denning's catalogue is taken from the *Companion to The Observatory* for 1909:

	Radiant α	Radiant δ	
Jan. 2-3	230°	+ 53°	Swift; long paths.
Apr. 20-22	271	+ 33	Swift.
May 1-6	338	— 2	Swift; streaks.
July 28	339	— 11	Slow; long.
Aug. 10-12	45	+ 57	Swift; streaks. The Perseids.
Nov. 14-16	150	+ 22	Swift; streaks. The Leonids.
Nov. 17-23	25	+ 43	Very slow; trains. The Andromids.
Dec. 10-12	108	+ 33	Swift; short.

The Perseids, with a maximum on Aug. 11, are visible for a considerable period and their radiant point exhibits a motion to E. N. E. among the stars of about 1° per day. Its position for July 19 is about $\alpha = 19°$, $\delta = +50°$ and for Aug. 16 about $\alpha = 53°$, $\delta = +58°$.

COMET NOTES.

NEW ELEMENTS OF COMET 1890 VII SPITALER.—In *A. N.* 4371 Dr. F. Hopfer of Triest gives new elements of Spitaler's periodic comet for the apparition of 1903, and shows that the orbit was materially changed by the perturbations by Jupiter in the interval 1890 to 1903 and that if a proper ephemeris had been computed for 1903 the comet might have been found. The new elements are as follows:

Epoch 1903 Dec. 11.5 Berlin m. t.

$M = 359^\circ\ 56'.3$
$\omega = 19\ \ 04.3$
$\Omega = 42\ \ 18.8$
$i = 11\ \ 33.3$
$\phi = 25\ \ 28.6$
$\mu = 520''.138$
$\log a = 0.5559$
$\log q = 0.3116$

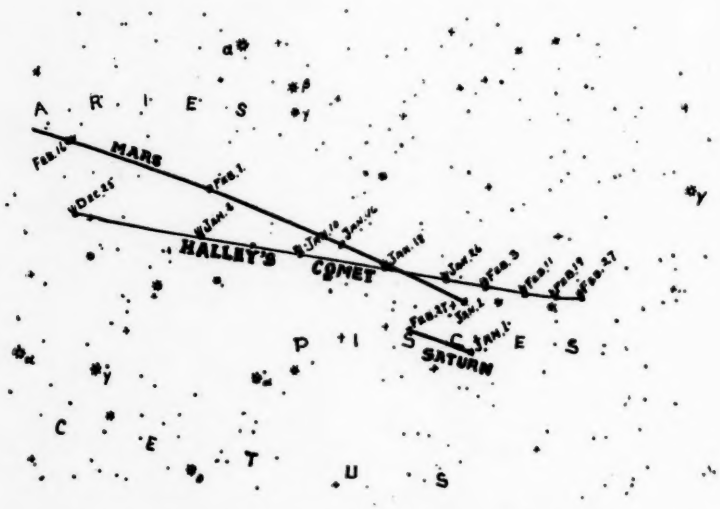
These elements give a period of 6.82 years instead of 6.42.

EPHEMERIS OF HALLEY'S COMET.—The following ephemeris has been calculated from the elements by Cowell and Crommelin as modified by Father Searle in the last number of POPULAR ASTRONOMY.

$T = 1910$ April 19.692
$\omega = 111^\circ\ 42'\ 16''$
$\Omega = 57\ \ 16\ \ 12$ } 1910.0
$i = 163\ \ 12\ \ 42$
$\log a = 1.253950$
$\log c = 9.985550$

Observations on Dec. 7 and 8 are represented closely by these elements.

On the night of December 18 the comet was easily seen in the five-inch finder and the sixteen-inch telescope revealed a stellar nucleus of about the tenth magnitude. A very faint tail could be traced for about 15′ from the head. The diagram shows the path of the comet during January and February.



APPARENT PATHS OF HALLEY'S COMET, MARS AND SATURN DURING JANUARY AND FEBRUARY, 1910

Greenwich Midnight 1910	α 1910.0 h m s	δ 1910.0 ° ′ ″	log r	log Δ	Brightness
Jan. 2	2 12 54.5	+11 18 46	0.3042	0.1507	15
6	1 59 47.5	10 43 31	0.2920	0.1608	15
10	1 47 56.8	10 11 31	0.2794	0.1719	15
14	1 37 20.8	9 43 7	0.2662	0.1836	15
18	1 27 54.7	9 18 30	0.2525	0.1956	15
22	1 19 32.3	8 57 35	0.2382	0.2074	16
26	1 12 07.4	8 40 10	0.2233	0.2189	16
30	1 05 33.6	+ 8 26 03	0.2077	0.2297	16

The brighteness Sept. 11, 1909, is taken as unity.

CONTINUED EPHEMERIS OF HALLEY'S COMET.—A letter has been received at this observatory from Father G. M. Searle, C. S. P. of New York, giving the following "Continued Ephemeris of Halley's comet, T assumed to be April $19^d.692$ Gr. M. T."

Gr. M. Noon		R. A. 1910.0 h m s	Decl. ° ′	log Δ	Br. Sept. 11 = 1
1910 Jan.	2	2 14 37	+11 23.3		
	4	2 7 50	11 5.2	0.154	18
	6	2 1 21	10 47.8		
	8	1 55 11	10 31.1	0.165	18
	10	1 49 21	10 15.3		
	12	1 43 49	10 0.4	0.176	18
	14	1 38 35	9 46.4		
	16	1 33 39	9 33.4	0.188	18
	18	1 29 0	9 21.3		
	20	1 24 38	9 10.2	0.200	19
	22	1 20 31	9 0.0		
	24	1 16 38	8 50.6	0.212	19
	26	1 12 59	8 42.1		
	28	1 9 34	8 34.5	0.223	19
	30	1 6 21	8 27.6		
Feb.	1	1 3 18	+ 8 21.5	0.234	20

A telegram has been received at this observatory from Smith College Observatory, Northampton, Mass., stating that Halley's comet was visible December 4, in a three-inch telescope.

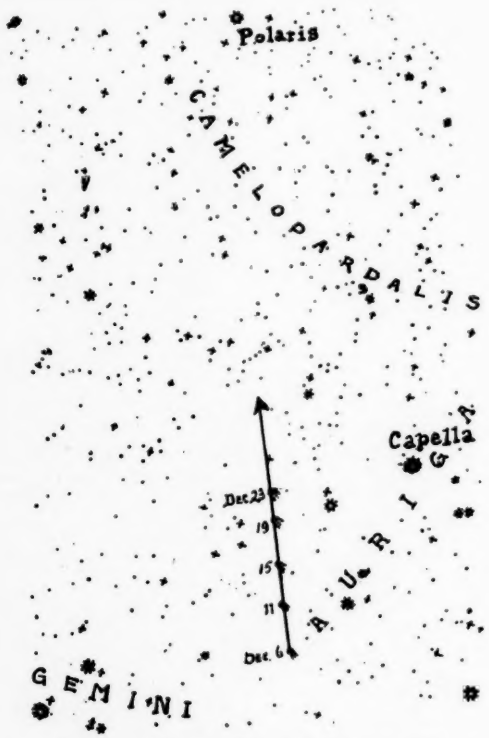
Astronomical Bulletin, No. 370,
Harvard College Observatory,
Cambridge, Mass., Dec. 6, 1909.

NEW COMET *e* 1909 (DANIEL.—A new comet was discovered by Mr. Zaccheus Daniel of Princeton on the night of December 6. It was in the constellation of Auriga about equally distant from the stars θAurigae and θ Geminorum, and about two degrees below the line joining those stars. Its motion is slow and almost due north, about five-sixths of a degree per day. The accompanying chart will indicate to the reader the apparent course of the comet among the stars with a fair degree of accuracy.

The comet is visible in a small telescope but is rather diffuse, perhaps 5′ in diameter, approximately round and without any very sharply defined nucleus. The following observations have come to hand:

G. M. T.	App. α	App. δ	Observer	Place
	h m s	° ′ ″		
1909 Dec. 6.599	6 16 30	+33 50	Daniel	Princeton
7.6605	16 42.1	+34 44 22	Barnard	Williams Bay
7.7243	16 44.0	+34 47 38	Wilson	Northfield
7.8759	16 44.0	+34 55 15	Daniel	Princeton
8.5208	16 52.5	+35 27.6	Metcalf	Taunton
8.5870	16 57.6	+35 30 53	Smith Coll.	Northampton
8.6564	16 59.6	+35 34 28	Wilson	Northfield
8.7097	16 59.3	+35 37 06	Daniel	Princeton
9.6159	17 13.7	+36 22 12	Daniel	Princeton
9.6613	17 14.7	+36 23 52	Wilson	Northfield
18.6631	6 17 11.2	+43 22 07	Wilson	Northfield

It is evident from an inspection of these that some, if not all, of the observers are subject to considerable personal equation in measuring the right ascension of the comet. The declinations are quite consistent with each other, but the right ascensions are inconsistent by even 2^s in some cases.



Apparent Path of Daniel's Comet *e* 1909.

The following elements, received by cablegram from Kiel through the courtesy of Harvard College Observatory, must therefore be regarded as quite uncertain. They were computed by Ebell at Kiel from observations on December 7, 8 and 9.

PRELIMINARY ELEMENTS OF COMET *e* 1909 DANIEL.

T = Dec. 5.56, 1909
$\omega = 9^\circ\ 16'$
$\Omega = 73\ \ 33$
$i = 25\ \ 57$
$q = 1.573$

These bear some resemblance to the elements of the comet 1867 I, which was referred to last month in the article on the Saturn, Uranus and Neptune families of comets. It will be fortunate, indeed, if this should turn out to be the member of the Uranus family which has been due for a couple of years.

EPHEMERIS OF COMET *e* 1909.

	α			δ			Brightness
	h	m	s	°	′		
Dec. 11	6	17	43	+37	55		1.00
15		18	26	+41	08		
19		18	52	+44	10		
23	6	19	06	+46	59		0.90

VARIABLE STARS.

THE ALGOL VARIABLE Z (26.1900) VULPECULAE.—In *A. N.* 4367 Mr. T. H. Astbury of Wallingford, England, gives new elements of this variable derived from observations of seventeen minima within the interval 1898-1909. The period appears to be 2.4550 days. The magnitude ranges from about 7.3 to 8.5 and the change of light occupies about six hours.

Minimum = 1908 Dec. 9 $6^h\ 0^m$ (2418285.250) + $2^d.455$ E.

VARIABLE 21.1909 ANDROMEDAE.—In *A. N.* 4367 Mr. F. Van Biesbroeck gives elements of this variable, and states that it is of the Algol type. The normal brightness is about magnitude 8.6 and at minimum it descends to about 11.5^m. The decrease occupies about five hours and the increase about six hours.

Minimum = 2418604.49 Gr. m. t. + $24^d.115$ E.

The position for 1900.0 is $\alpha = 23^h\ 58^m\ 10^s$, $\delta = +32^\circ\ 17'.3$.

NEW VARIABLE 43.1909 DRACONIS.—In *A. N.* 4371 Miss Mary W. Whitney of Vassar College Observatory calls attention to the variability of the star BD+ 58°1785, which she has used as a comparison star for SX Draconis. Its BD magnitude is $9^m.3$. On August 14 it wasc $10^m.5$; on August 19 as faint or fainter. Various later observations place it at about its normal brightness, $9^m.3$ -$9^m.5$. magnitude is $9^m.3$. On August 14 it was $10^m.5$; on August 19 as faint or faint- Whitney also states that thus far her comparisons of SX Draconis imply that this star is of the Algol type, as no marked decrease in brightness has been observed.

The positions of the two stars for 1900.0 are

SX Draconis	$\alpha = 18^h\ 2^m\ 25^s$	$\delta = +58^\circ\ 19'.7$
43.1909	18 3 03	+58 23 .3

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time beginning with noon. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

SY Androm.

	d	h
Feb.	1	1

U Cephei

	d	h
Feb.	1	10
	3	22
	6	10
	8	22
	11	9
	13	21
	16	9
	18	21
	21	9
	23	21
	26	8
	28	20

Z Persei

	d	h
Feb.	2	12
	5	13
	8	15
	11	16
	14	17
	17	19
	20	20
	23	21
	26	23

RY Persei

	d	h
Feb.	1	2
	7	23
	14	19
	21	16
	28	13

RZ Cassiop.

	d	h
Feb.	1	21
	3	2
	4	6
	5	11
	6	16
	7	20
	9	1
	10	6
	11	10
	12	15
	13	20
	15	0
	16	5
	17	10
	18	14
	19	19
	21	0
	22	5
	23	9
	24	14
	25	19
	26	23
	28	4

ST Persei.

	d	h
Feb.	1	18
	4	9
	7	1
	9	16
	12	8
	14	23
	17	15
	20	6
	22	22
	25	13
	28	5

RX Cephei

	d	h
Feb.	3	20

β Persei

	d	h
Feb.	3	0
	5	21
	8	18
	11	15
	14	11
	17	8
	20	5
	23	2
	25	23
	28	19

RT Persei

	d	h
Feb.	1	7
	2	3
	2	23
	3	20
	4	16
	5	13
	6	9
	7	5
	8	2
	8	22
	9	19
	10	15
	11	11
	12	8
	13	4
	14	0
	14	21
	15	17
	16	14
	17	10
	18	6
	19	3
	19	23
	20	20
	21	16
	22	12
	23	9
	24	5
	25	1
	25	22
	26	18

RT Persei

	d	h
Feb.	27	15
	28	11

λ Tauri

	d	h
Feb.	1	3
	5	2
	9	1
	12	23
	16	22
	20	21
	24	20
	28	19

RW Tauri

	d	h
Feb.	1	16
	4	11
	7	5
	10	0
	12	18
	15	13
	18	7
	21	2
	23	20
	26	15

RV Persei

	d	h
Feb.	1	13
	3	12
	5	11
	7	11
	9	10
	11	10
	13	9
	15	8
	17	8
	19	7
	21	6
	23	6
	25	5
	27	4

RW Persei

	d	h
Feb.	8	10
	21	15

RS Cephei

	d	h
Feb.	2	10
	14	20
	27	6

RY Aurigae

	d	h
Feb.	2	15
	5	9
	8	2
	10	20
	13	13
	16	7
	19	0
	21	18

RY Aurigae

	d	h
Feb.	24	11
	27	5

RZ Aurigae

	d	h
Feb.	3	23
	6	23
	10	0
	13	0
	16	1
	19	1
	22	1
	25	2
	28	2

RW Geminorum

	d	h
Feb.	3	17
	6	14
	9	10
	12	7
	15	4
	18	1
	20	22
	23	18
	26	15

U Columbae

	d	h
Feb.	2	20
	5	15
	8	10
	11	5
	14	0
	16	19
	19	15
	22	10
	25	5
	28	0

RW Monoc.

	d	h
Feb.	1	5
	3	3
	5	0
	6	22
	8	20
	10	18
	12	15
	14	13
	16	11
	18	9
	20	6
	22	4
	24	2
	26	0
	27	21

RX Gem.

	d	h
Feb.	11	19
	24	0

RU Monoc.

	d	h
Feb.	1	6
	2	4
	3	1
	3	23
	4	20
	5	18
	6	15
	7	13
	8	10
	9	8
	10	5
	11	3
	12	0
	12	22
	13	19
	14	17
	15	14
	16	12
	17	9
	18	7
	19	4
	20	2
	20	23
	21	21
	22	18
	23	16
	24	13
	25	11
	26	8
	27	6
	28	4

RY Gem.

	d	h
Feb.	9	21
	19	4
	28	11

R Canis Maj.

	d	h
Feb.	1	14
	2	17
	3	21
	5	0
	6	3
	7	6
	8	10
	9	13
	10	16
	11	19
	12	23
	14	3
	15	5
	16	8
	17	12
	18	15
	19	18
	20	21
	22	1
	23	4

Minima of Variable Stars of the Algol Type.—Continued.

R Canis Maj.

	d	h
Feb.	24	7
	25	11
	26	14
	27	11
	28	20

Y Camelop.

	d	h
Feb.	3	4
	6	12
	9	19
	13	2
	16	10
	19	17
	23	0
	26	8

RR Puppis

	d	h
Feb.	3	8
	9	18
	16	5
	22	15

V Puppis

	d	h
Feb.	2	10
	3	20
	5	7
	6	18
	8	5
	9	16
	11	3
	12	14
	14	1
	15	12
	16	23
	18	10
	19	20
	21	7
	22	18
	24	5
	25	16
	27	3
	28	14

X Carinæ

	d	h
Feb.	1	6
	2	8
	3	10
	4	12
	5	14
	6	16
	7	18
	8	20
	9	22
	11	0
	12	2
	13	4
	14	6
	15	8
	16	10
	17	12
	18	14
	19	16

X Carinæ

	d	h
Feb.	20	18
	21	19
	22	21
	23	23
	25	1
	26	3
	27	5
	28	7

S Cancri

	d	h
Feb.	5	7
	14	20
	24	7

S Velorum

	d	h
Feb.	2	22
	8	20
	14	19
	20	17
	26	15

Y Leonis

	d	h
Feb.	2	8
	4	0
	5	17
	7	9
	9	1
	10	18
	12	10
	14	3
	15	19
	17	12
	19	4
	20	21
	22	13
	24	6
	25	22
	27	15

RR Velorum

	d	h
Feb.	1	7
	3	3
	5	0
	6	20
	8	17
	10	13
	12	10
	14	6
	16	3
	17	23
	19	20
	21	16
	23	13
	25	9
	27	6

SS Carinæ

	d	h
Feb.	2	11
	5	19
	9	2
	12	9
	15	16

SS Carinæ

	d	h
Feb.	19	0
	22	7
	25	14
	28	21

RW Urs. Maj.

	d	h
Feb.	5	23
	13	7
	20	15
	27	23

Z Draconis

	d	h
Feb.	1	22
	3	6
	4	15
	5	23
	7	8
	8	17
	10	1
	11	10
	12	18
	14	3
	15	11
	16	20
	18	5
	19	13
	20	22
	22	6
	23	15
	25	0
	26	8
	27	17

SS Centauri

	d	h
Feb.	2	14
	5	1
	7	13
	10	0
	12	12
	14	23
	17	11
	19	22
	22	10
	24	21
	27	9

L Libræ

	d	h
Feb.	2	0
	4	8
	6	16
	9	0
	11	8
	13	16
	15	23
	18	7
	20	15
	23	0
	25	7
	27	15

U Coronæ

	d	h
Feb.	2	10
	5	21
	9	7
	12	18
	16	5
	19	16
	23	3
	26	14

SX Ophiuchi

	d	h
Feb.	1	17
	3	18
	5	20
	7	21
	9	23
	12	0
	14	2
	16	4
	18	5
	20	7
	22	8
	24	10
	26	11
	28	13

SW Ophiuchi

	d	h
Feb.	1	10
	3	20
	6	7
	8	18
	11	5
	13	15
	16	2
	18	13
	20	23
	23	10
	25	21
	28	7

R Aræ

	d	h
Feb.	4	0
	8	10
	12	20
	17	6
	21	17
	26	3

U Ophiuchi

	d	h
Feb.	1	9
	2	5
	3	1
	3	21
	4	17
	5	13
	6	9
	7	6
	8	2
	8	22
	9	18
	10	14
	11	10
	12	6

U Ophiuchi

	d	h
Feb.	13	2
	13	23
	14	19
	15	15
	16	11
	17	7
	18	3
	18	23
	19	19
	20	16
	21	12
	22	8
	23	4
	24	0
	24	20
	25	16
	26	13
	27	9
	28	5

SZ Herculis

	d	h
Feb.	1	16
	2	11
	3	7
	4	3
	4	22
	5	18
	6	14
	7	9
	8	5
	9	0
	9	20
	10	16
	11	11
	12	7
	13	3
	13	22
	14	18
	15	14
	16	9
	17	5
	18	0
	18	20
	19	16
	20	11
	21	7
	22	3
	22	22
	23	18
	24	13
	25	9
	26	5
	27	0
	27	20
	28	16

Z Herculis

	d	h
Feb.	1	4
	5	4
	9	4
	13	3

Minima of Variable Stars of the Algol Type.—Continued.

Z Herculis

	d	h
Feb.	17	3
	21	3
	25	3

RS Sagittarii

	d	h
Feb.	1	15
	4	0
	6	10
	8	20
	11	6
	13	16
	16	2
	18	12
	20	22
	23	8
	25	18
	28	4

V Serpentis

	d	h
Feb.	2	11
	5	22
	9	8
	12	19
	16	6
	19	17
	23	4
	26	15

RZ Draconis

	d	h
Feb.	1	12
	2	14
	3	17
	4	19
	5	22
	7	0
	8	2
	9	5
	10	7
	11	10
	12	12

RZ Draconis

	d	h
Feb.	13	15
	14	17
	15	20
	16	22
	18	0
	19	3
	20	5
	21	8
	22	10
	23	13
	24	15
	25	18
	26	20
	27	22

RX Herculis

	d	h
Feb.	1	9
	2	7
	3	4
	4	1
	4	23
	5	20
	6	17
	7	15
	8	12
	9	9
	10	7
	11	4
	12	1
	12	23
	13	20
	14	17
	15	15
	16	12
	17	9
	18	7
	19	4
	20	1
	20	23

RX Herculis

	d	h
Feb.	21	20
	22	17
	23	15
	24	12
	25	10
	26	7
	27	4
	28	2
	28	23

SX Sagittarii

	d	h
Feb.	1	9
	3	10
	5	12
	7	14
	9	16
	11	18
	13	20
	15	22
	17	23
	20	1
	22	3
	24	5
	26	7
	28	9

RR Draconis

	d	h
Feb.	2	12
	5	18
	8	4
	11	0
	13	20
	16	16
	19	12
	22	8
	25	4
	28	0

U Scuti

	d	h
Feb.	1	16
	2	15
	3	14
	4	13
	5	12
	6	11
	7	10
	8	9
	9	8
	10	7
	11	6
	12	4
	13	3
	14	2
	15	1
	16	0
	16	23
	17	22
	18	21
	19	20
	20	19
	21	18
	22	17
	23	15
	24	14
	25	13
	26	12
	27	11
	28	10

RX Draconis

	d	h
Feb.	2	2
	4	0
	5	21
	7	19
	9	16
	11	13
	13	11
	15	8
	17	6

RX Draconis

	d	h
Feb.	19	3
	21	1
	22	22
	24	20
	26	17
	28	15

RV Lyræ

	d	h
Feb.	3	13
	7	4
	10	18
	14	8
	17	23
	21	13
	25	4
	28	18

U Sagittæ

	d	h
Feb.	2	19
	6	4
	9	13
	12	22
	16	7
	19	16
	21	1
	26	11

Z Vulpeculæ

	d	h
Feb.	1	10
	6	11
	11	12
	16	14
	21	15
	26	16

SY Cygni

	d	h
Feb.	2	0
	8	0
	14	0
	20	0
	26	0

Maxima of Variable Stars of Short Period not of the Algol Type.

Unless otherwise indicated the times of maxima only are given; and the times of minima may be found by subtracting the interval printed in parentheses under the names of the stars.

SX Cassiop.

	d	h
Feb.	13	6

SY Cassiop.

	d	h
Feb.	2	8
	6	10
	10	12
	14	13
	18	15
	22	17
	26	19

RW Cassiop.

	d	h
	(—5	19)
Feb.	2	7
	17	2

SU Cassiop.

	d	h
	(—0	22)
Feb.	1	5
	3	4
	5	3
	7	2
	9	0

SU Cassiop.

	d	h
Feb.	10	23
	12	22
	14	21
	16	20
	18	18
	20	17
	22	16
	24	15
	26	13
	28	12

SV Persei

	d	h
Feb.	7	16
	18	19

RX Aurigæ

	d	h
	(—4	0)
Feb.	7	20
	19	11

SX Aurigæ

	d	h
Feb.	1	22
	3	11

SX Aurigæ

	d	h
Feb.	5	0
	6	13
	8	2
	9	14
	11	3
	12	16
	14	5
	15	17
	17	6
	18	19

Maxima of Variable Stars of Short Period not of the Algol Type.—Con.

SX Aurigæ

	d	h
Feb.	20	8
	21	20
Feb.	23	9
	24	22
	26	11
	27	23

SY Aurigæ

Feb.	2	4
	12	8
	22	11
Feb.		

Y Aurigæ

	(—0	18)
Feb.	1	16
	5	12
	9	9
	13	5
	17	2
	20	23
Feb.	24	19
	28	16

RZ Geminorum

	(—7	7)
Feb.	1	15
	7	3
	12	16
	18	4
	23	16

RS Orionis

	(—2	0)
Feb.	1	6
	8	19
	16	9
	23	22

T Monoc.

	(—9	23)
Feb.	6	18

W Geminorum

	(—2	2)
Feb.	1	15
	9	13
	17	11
	25	9
Feb.		

ξ Geminorum

	(—5	0)
Feb.	9	21
	20	1

RU Camelop.

	(—9	12)
Feb.	8	6

V Carinæ

	(—2	4)
Feb.	6	2
	12	19
	19	11
	26	4

T Velorum

	d	h
	(—1	10)
Feb.	3	7
	7	3
	12	14
	17	5
	21	21
	26	12

W Carinæ

	(—1	0)
	3	7
	7	16
	12	1
	16	10
	20	19
	25	4

S Muscæ

	(—3	11)
Feb.	5	12
	15	4
	24	19
Feb.		

T Crucis

	(—2	2)
	1	2
	7	20
	14	14
	21	7
	28	1
Feb.		

R Crucis

	(—1	10)
	5	17
	11	13
	17	8
	23	4

S Crucis

	(—1	12)
	5	12
	10	4
	14	21
	19	13
	24	6
	28	22

RZ Centauri

	1	10
Feb.	2	9
	3	7
	4	6
	5	4
	6	3
Feb.	7	1
	8	0
	8	22
	9	21
	10	19
	11	18
	12	16
Feb.	13	15
	14	13
	15	12

RZ Centauri

	d	h
	16	10
Feb.	17	9
	18	7
	19	6
	20	4
	21	3
	22	1
Feb.	23	0
	23	22
	24	21
	25	19
	26	18
	27	16
	28	15
Feb.		

W Virginis

	(—8	5)
Feb.	15	14

V Centauri

	(—1	11)
	3	11
	8	23
	14	11
	19	23
	25	10
Feb.		

R Tri. Austr.

	(—1	0)
	2	22
	6	7
	9	17
	13	2
	16	11
	19	21
Feb.	23	6
	26	15

S Tri. Austr.

	(—2	2)
	6	19
Feb.	13	2
	19	10
Feb.	25	18

S Normæ

	(—4	10)
Feb.	5	0
	12	21
	22	16
Feb.		

RV Scorpii

	(—1	10)
	2	19
	8	21
	14	22
Feb.	21	0
	27	1

RV Ophiuchi Minimum

	3	11
	7	3
Feb.	10	20
	14	12

RV Ophiuchi

	d	h
Feb.	18	5
	21	21
Feb.	25	14

X Sagittarii

	(—2	22)
	5	3
	12	4
	19	4
	26	4

Y Ophiuchi

Feb.	(—6	5)
	6	21
	24	0

W Sagittarii

	(—3	0)
Feb.	3	23
	11	14
	19	4
	26	18

Y Sagittarii

	(—2	2)
Feb.	5	4
	10	23
	16	18
	22	12
	28	7

U Sagittarii

	(—2	23)
Feb.	2	10
	9	4
	15	22
	22	16

β Lyræ

Feb.	(—3	7)
	(—3	2)
	4	7
	10	13
	17	5
	23	11

k Pavonis

Feb.	(—4	7)
	8	12
	17	14
	26	17
Feb.		

U Aquilæ

	(—2	4)
Feb.	1	7
	8	8
	15	9
	22	9
Feb.		

U Vulpeculæ

	(—2	3)
Feb.	6	0
	13	23
	21	23

SU Cygni

	d	h
	(—1	7)
Feb.	3	1
	6	21
	10	17
	14	14
	18	10
	22	6
	26	3

η Aquilæ

	(—2	6)
Feb.	6	15
	13	20
	21	0
	28	4

S Sagittæ

	(—3	10)
Feb.	4	23
	13	8
	21	17

X Vulpeculæ

	(—2	1)
	5	23
	12	6
	18	14
	24	21

V Vulpeculæ Minimum

Feb.	13	14

X Cygni

	(—6	19)
Feb.	8	9
	24	18

T Vulpeculæ

	(—1	10)
Feb.	4	6
	8	17
	13	3
	17	14
	21	0
	26	11

TX Cygni

Feb.	3	23
	18	17

VY Cygni

	(—2	14)
Feb.	2	3
	10	0
	17	21
	25	17

VZ Cygni

	(—1	1)
Feb.	2	20
	7	16
	12	13
	17	10
	22	6
	27	3

Maxima of Variable Stars of Short Period not of the Algol Type.
Continued.

Y Lacertæ		δ Cephei		V Lacertæ		X Lacertæ		RS Cassiop.	
d	h	d	h	d	h	d	h	d	h
(—1	10) Feb.	18	2	(—1	16) Feb.	21	8 Feb.	8	12
Feb. 2	18	23	11 Feb.	1	16	26	19	14	19
7	2	28	20	6	16			21	3
11	10	Z Lacertæ		11	16	SW Cassiop.		27	10
15	18 Feb.	11	19	16	15 Feb.	2	10		
20	1	22	16	21	15	8	1		
24	9			26	14	13	11		
28	17	RR Lacertæ				18	21		
		(—1	2)			24	8	RY Cassiop.	
δ Cephei		Feb. 6	12	X Lacertæ					
Feb. 2	0	12	23 Feb.	5	0	RS Cassiop.		(—7	10)
7	8	19	9	10	11	(—1	19) Feb.	11	11
12	17	25	19	15	22 Feb.	2	5	23	15

Approximate Magnitudes of Variable Stars on Dec. 1, 1909.
[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900 h	m	Decl. 1900 °	′	Magn.	Name.	R. A. 1900 h	m	Decl. 1900 °	′	Magn.
S. Sculpt.	0	10.3	−32	36	8.0 *i*	R Persei	3	23.7	+35	20	11.3 *i*
X Androm.		10.8	+46	27	13.0*d*	Nov. Per.	2	24.4	+43	34	12.3
T Androm.		17.2	+26	26	11.5*d*	T Tauri	4	16.2	+19	18	12.2*d*
T Cassiop.		17.8	+55	14	8.5 *i*	W Tauri		22.2	+15	49	12.0*d*
R Androm.		18.8	+38	1	9.2*d*	R Tauri		22.8	+ 9	56	<13.5
S Ceti		19.0	— 9	53	8.5	S Tauri		23.7	+ 9	44	13.5 *i*
Y Cephei		31.3	+79	48	13.0*d*	T Camelop.		30.4	+65	57	10.5 *i*
U Cassiop.		40.8	+47	43	11.5*d*	R Pictoris		43.5	—49	26	9.0
RW Androm.		41.9	+32	8	12.4*d*	V Tauri		46.2	+17	22	9.8 *i*
V Androm.		44.6	+35	6	13.2*d*	R Orionis		53.6	+ 7	59	10
RR Androm.		45.9	+33	50	<13	V Orionis	5	0.8	+ 3	59	12.0 *i*
RV Cassiop.		47.1	+46	53	<13	T Leporis		0.6	—22	2	8.0
W Cassiop.		49.0	+58	1	9.3*d*	R Aurigae		9.2	+53	28	11.2 *i*
Z Ceti	1	1.6	— 2	1	12.6*d*	S Aurigae		20.5	+34	4	8.5
U Androm.		9.8	+40	11	<13.5	W Aurigae		20.1	+36	39	<14
S Piscium		12.4	+ 8	24	<13.5	S Orionis		24.1	— 4	46	10.5
S Cassiop.		12.3	+72	5	9.7 *i*	T Orionis		30.9	— 5	32	10.0
U Piscium		17.7	+12	21	11 *i*	S Camelop.		30.2	+68	45	10.5 *i*
R Piscium		25.5	+ 2	22	<13.5	RR Tauri		33.3	+26	19	12
RU Androm.		32.8	+38	10	9.8 *i*	U Aurigae		35.6	+31	59	8.0
Y Androm.		33.7	+38	50	11.0*d*	SU Tauri		43.2	+19	2	<13.5
X Cassiop.		49.8	+58	46	10.7*d*	Z Tauri		46.7	+15	46	9.5
U Persei		53.0	+54	20	8.0*d*	U Orionis		49.9	+20	10	11.0*d*
S Arietis		59.3	+12	3	11.0	V Camelop.		49.4	+74	30	13.5
R Arietis	2	10.4	+24	35	13.0*d*	Z Aurigae		53.6	+53	18	12.5
W Androm.		11.2	+43	50	9.6*d*	R Octantis		56.4	—86	26	12.5*d*
Z Cephei		12.8	+81	13	12.0 *i*	X Aurigae	6	4.4	+50	15	13.0
o Ceti		14.3	— 3	26	6.5*d*	SS Aurigae		5.8	+47	46	<13.5
S Persei		15.7	+58	8	9.0	V Aurigae		17.2	— 2	9	9.5
R Ceti		20.9	— 0	38	12.8	R Monoc.		33.7	+ 8	49	11
RR Persei		21.7	+50	49	<13	S Lyncis		35.9	+58	0	14
U Ceti		28.9	—13	35	9.5 *i*	X Gemin.		40.7	+30	23	10.2 *i*
RR Cephei		30.4	+80	42	10.0 *i*	Y Monoc.		53.3	+11	22	13.0
R Trianguli		31.0	+33	50	9.8*d*	R Lyncis		53.0	+55	28	9.5 *i*
T Arietis		42.8	+17	6	9.1	RS Gemin.		55.2	+30	40	12
W Persei		43.2	+56	34	9	V Can. Min.	7	1.5	+ 9	2	11.5*d*
U Arietis	3	5.5	+14	25	<13.5	R Gemin.		1.3	+22	52	8
X Ceti		14.3	— 1	26	12.1 *i*	RR Monoc.		12.4	+ 1	17	9.5
Y Persei		20.9	+43	50	9.6	Z Puppis		28.3	—20	27	7.5

Approximate Magnitudes of Variable Stars on Dec. 1, 1909.—Con.

Name.	R. A. 1900 h m	Decl. 1900 ° ′	Magn.	Name.	R. A. 1900 h m	Decl. 1900 ° ′	Magn.
R Carinae	9 29.7	−62 21	7.0*d*	RU Sagit.	19 51.8	−42 7	7.5
S Pyxidis	0.7	−24 41	8.8	RR Aquilae	52.4	− 2 11	12.0*d*
RR Hydrae	40.4	−23 34	11.3*d*	RS Aquilae	53.7	− 8 9	12.0*i*
R Urs. Maj.	10 37.6	+69 18	12.6	Z Cygni	58.6	+49 46	13
T Urs. Maj.	12 31.8	+60 2	12.4	SY Aquilae	20 2.3	+12 39	12.8
RS Urs. Maj.	34.4	+59 2	<13.5	S Cygni	3.5	+57 42	11.0*d*
S Urs. Maj.	39.6	+61 38	7.5*i*	R Capricorni	5.7	−14 34	10.5*i*
T Urs. Min.	13 32.6	+73 56	11.5*i*	S Aquilae	7.0	+15 19	9.0*i*
R Can. Ven.	44.6	+40 2	7.5	RU Aquilae	8.0	+12 42	10.1*i*
U Urs. Min.	14 15.1	+67 15	9.5*d*	W Capricorni	8.6	−22 17	<14
S Bootis	19.5	+54 16	10.0*d*	Z Aquilae	9.8	− 6 27	10.2*i*
R Camelop.	25.1	+84 17	10.8*d*	RS Cygni	9.8	+38 28	8.0
R Bootis	32.8	+27 10	9.0*d*	R Delphini	10.1	+ 8 47	8.5*i*
S Coronae	15 17.3	+31 44	12.0*i*	RT Capricorni	11.3	−21 38	7.0
S Urs. Minn.	33.4	+78 58	9.5*i*	SX Cygni	11.6	+30 46	11.5*d*
V Coronae	46.0	+39 52	11*i*	RT Sagittarii	11.1	−39 25	10.5*d*
RR Herculis	16 1.5	+50 46	8.5	U Cygni	16.5	+47 35	8.6*d*
U Serpentis	2.5	+10 12	11.5*d*	RW Cygni	25.2	+39 39	9.0*d*
RU Herculis	6.0	+25 20	10*i*	RU Capricorni	26.7	−22 2	12*i*
W Coronae	11.8	+38 3	13	Z Delphini	28.1	+17 7	11.5*d*
U Herculis	21.4	+19 7	9.5*d*	ST Cygni	29.9	+54 38	14.0
W Herculis	31.7	+37 32	13.0*i*	Y Delphini	36.9	+11 31	<14
R Draconis	32.4	+66 58	12.0*d*	S Delphini	38.5	+16 44	10.0*i*
S Herculis	47.4	+15 7	10.0*d*	V Cygni	38.1	+47 47	12.2*i*
RS Scorpii	48.4	−44 56	11.5*d*	Y Aquarii	39.2	− 5 12	10.8*i*
RR Scorpii	50.2	−30 25	7.0*i*	T Delphini	40.7	−16 2	<14
T Draconis	54.8	+58 14	10.1*i*	V Aquarii	41.8	+ 2 4	8.0*i*
— Draconis	54.7	+58 13	11.5	W Aquarii	41.2	− 4 27	10.7*d*
RY Herculis	55.4	−19 29	8.5	U Capricorni	42.6	−15 9	10.0
V Draconis	56.3	+54 53	9.5	V Delphini	43.2	+18 58	11.4*i*
R Pavonis	18 3.3	−63 38	12.5	T Aquarii	44.7	− 5 31	12.8*d*
T Herculis	5.3	+31 0	11.7*d*	RZ Cygni	48.5	+46 59	9.5*i*
W Draconis	5.4	+65 56	11.8*d*	S Indi	49.0	−54 42	8.5
W Lyrae	11.5	+36 38	10.5*d*	X Delphini	50.3	+17 16	13.5*d*
RV Sagittarii	21.4	−33 23	11.5*d*	R Vulpeculae	59.9	+23 26	8.0*i*
SV Herculis	22.3	+24 58	8.8*i*	V Capric.	21 1.8	−24 19	11.0*d*
RY Lyrae	41.2	+34 34	11.2*d*	TW Cygni	1.8	+29 0	11.0*i*
RW Lyrae	42.1	+43 32	<13	X Cephei	3.6	+82 40	11.5*i*
RX Lyrae	50.4	+32 42	<14	RS Aquarii	5.8	− 4 27	13.5*d*
Z Lyrae	56.0	+34 49	12.0*i*	Z Capricorni	5.8	−16 35	13.0
RT Lyrae	57.8	+37 22	12.7*i*	R Equulei	8.4	+12 23	13.3
R Aquilae	19 1.6	+ 8 5	9.0*d*	T Cephei	8.2	+68 5	8.7*d*
V Lyrae	5.2	+29 30	<13.5	RR Aquarii	9.8	− 3 19	12.5*d*
S Lyrae	9.1	+25 50	<14	XPegasi	16.3	+14 2	13.8
RS Lyrae	9.3	+33 15	13.0*d*	T Capricorni	16.5	−15 35	13.3*d*
RU Lyrae	9.1	+41 8	12.6*d*	Y Capricorni	28.9	−14 25	12
U Draconis	9.9	+67 7	11.3*i*	S Cephei	36.5	+78 10	9.0*d*
Z Sagittarii	13.8	−21 7	13.3*d*	RU Cygni	37.3	+53 52	9.1
TZ Cygni	13.4	+50 0	10.5	RR Pegasi	40.0	+24 33	9.5
U Lyrae	16.6	+37 42	10.8	Y Pegasi	56.0	+ 5 38	13.6*d*
T Sagittae	17.2	+17 28	9.9	U Aquarii	57.9	−17 6	10.5*i*
TY Cygni	29.8	+28 6	12.8*d*	RT Pegasi	59.8	+34 38	10.8*d*
RT Aquilae	33.3	+11 30	12.0*i*	T Pegasi	22 4.0	+12 3	13.0*i*
R Cygni	34.1	+49 58	9.5*d*	Y Pegasi	6.8	+13 52	10.0*i*
RV Aquilae	35.9	+ 9 42	13.0*d*	RS Pegasi	7.4	+14 4	<13
T Pavonis	39.5	−72 1	<13	R Pisc. Aust.	12.3	−30 6	11.8*d*
RT Cygni	40.8	+48 32	10.5*i*	X Aquarii	13.2	−21 24	12.0*i*
TU Cygni	43.3	+48 49	10.0*i*	RT Aquarii	17.7	−22 34	12.0
X Aquilae	46.5	+ 4 13	12.0*d*	T Gruis	19.9	−38 4	10.0*d*
χ Cygni	46.7	+32 40	11.5*d*	S Gruis	19.9	−48 57	11.3*d*

Approximate Magnitudes of Variable Stars on Dec. 1, 1909.—Con.

Name.	R. A. 1900 h	m	Decl. 1900 °	′	Magn.	Name.	R. A. 1900 h	m	Decl. 1900 °	′	Magn.
RV Pegasi	22	21.0	+29	58	9.0	R Aquarii	23	38.6	−15	50	10.3
R Indi		28.9	−67	48	10.0 *i*	Z Cassiop.		39.7	+56	2	10.4 *d*
S Lacertae		24.6	+39	48	10.6 *d*	Z Aquarii		47.1	−16	25	7.3 *i*
R Lacertae		38.8	+41	51	13.0 *i*	RR Cassiop.		50.7	+53	8	10.8 *i*
S Aquarii		51.8	−20	53	9.8 *d*	R Phoenicis		51.3	+50	21	9.5 *d*
RW Pegasi		59.2	+14	46	12.6	V Ceti		52.8	− 9	31	13.8 *d*
R Pegasi	23	1.6	+10	0	10.0 *d*	R Tucanae		52.2	−65	57	< 13
V Cassiop.		7.4	+59	8	12.2 *d*	Y Cassiop.		58.2	+55	7	14.0
W Pegasi		14.8	+25	44	8.8 *d*	R Cassiop.		53.3	+50	50	9.8 *i*
S Pegasi		15.5	+ 8	22	12.3 *i*	Z Pegasi		55.0	+25	21	8.8
Z Androm.		28.8	+48	16	10.7	W Ceti		57.0	−15	14	10.3 *d*
ST Androm.		33.8	+35	13	9.0						

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled by Mr. Leon Campbell of the Harvard College Observatory from observations made at the Vassar, Mt. Holyoke, Swartz and the Harvard Observatories including the South African Station of the latter.

GENERAL NOTES.

Miss M. E. Byrd, formerly of Carleton College, later of Smith College, is spending the winter at Washburn College, Topeka, Kansas, where, through the courtesy of the director, Professor H. I. Woods, she has the privilege of using the instruments of their well-equipped observatory.

The Total Eclipse of the Moon of November 27, 1909. I observed the eclipse of the Moon of November 27, 1909, with my refractor of 2.5 inches aperture. The eclipse was one of the most beautiful phenomena I have ever observed.

At the beginning of the eclipse the Moon was situated in Taurus, almost between the Pleiades and the Hyades. As the shadow of the Earth apparently transitted the Moon's disk, it seemed to be bounded by a strip of an ashen hue while the remaining portions of it were reds of various depths. At last when totality arrived, the entire disk of the Moon was a mass of exquisite colors; with the telescope could be made out, dark reds, lighter reds, and pinks, while to the unaided eye it appeared generally of a copper color. When totality was over and when the shadow of the Earth was apparently drawing off of the Moon's disk, it was bounded again by a strip of an ashen hue.

Chicago, Illinois. Frederick C. Leonard.

[The above note comes from our youngest correspondent, an enthusiastic amateur of thirteen years. Editor.]

Total Eclipse of the Moon. Halley's comet observed. The total eclipse of the Moon on November 27 was a beautiful spectacle here, the sky being very clear.

I availed myself of the eclipse during the total phase, to observe Halley's

comet, and had it at once in the field. Position R. A. $4^h\ 44^m\ 10^s$; Declination north 16° 18′. The comet, although small and faint, was an easy object in the ten-inch refractor. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.

PROBABILITY OF A TRANSIT OF HALLEY'S COMET. The following results may be of interest, as showing with some degree of accuracy the probability of a transit of Halley's comet over the Sun's disk next May.

If we assume the final orbit of Cowell and Crommelin to be correct, of course the time required for the comet to pass from perihelion to node becomes known, and the limits of time for the perihelion, to give a transit. The result seems to be as follows. The limits are April 19.34 and 19.90 G. M. T., giving April 19.62 for a central transit. If the value April 19.69 should be correct, of course the transit would be $\frac{19.69 - 19.62}{19.90 - 19.62} = \frac{1}{4}$ of the semi-diameter of the Sun from the center, which agrees with the result which I obtained from the assumption of that date for perihelion some time ago.

Of course the final values of Cowell and Crommelin will require some little correction, but still, as the margin for transit is so considerable, the phenomenon is really quite probable. It should occur at some time between May 18.52 and 18.75 G. M. T. GEORGE M. SEARLE, C. S. P.

New York.

THE TOTAL ECLIPSE OF THE MOON AS SEEN IN SAN FRANCISCO. On the evening of November the 26th, up to eight o'clock the sky was ideal for a lunar eclipse. The Moon shone brilliantly without a trace of a halo close round or distant, which showed the absence of either vapor or ice crystals in the upper atmosphere. The ominous branching cloud forms glided from the west, but fortunately they passed away, and in accurate accordance with prediction, the northeast limb near the Ocean of Storms was dimmed about 11:11 P. M. Aristarchus, the whitest crater on the Moon, was soon submerged, and at 11:30 Copernicus was reached. In less than forty-five minutes the unshadowed portion had assumed the various phases known as gibbous, half moon and crescent, while the submerged portion even to the rim continued to be discernible throughout the changing phases both before and after totality. A faint pinkish glow had already set in toward the northeasterly limb at 11:45 and at 12:16 the entire disk blushed from the shadow depths with due color and distinctness. This phase was not readily recognized at first on account of a yellowish glow that encircled the south, southwestern and western limb, even when fully submerged. This vestige of the usual golden luster, probably due to nearness to the shadow's edge, was retained more or less through the total phase, but moved southward and eastward as the Moon advanced centrally, and was chiefly eastward as it emerged into sunlight. The deepest pink shade was always on the tracts farthest from this sparsely shadowed rim.

Though not far past perigee the orb looked small when directly south, but conveyed a strong impression of its globularity of form. Many of the markings were recognizable without magnifying power, and an opera-glass showed several of the craters. Toward one o'clock A. M., the terms lurid and coppery, so often applied to the totally eclipsed aspect, gained their full significance,

but the deep flower-like pink noticeable in the eclipse of October 16th, 1902, was not attained. ROSE O'HALLORAN.

San Francisco, California.

SCHURIG'S HIMMELS-ATLAS. I should like to call the attention of teachers of Astronomy to the new edition of Schurig's Himmels-Atlas which has just been published. The old edition has been out of print for two years or more, and previous to that time the lettering was rather indistinct and faded, and perhaps on that account it may have fallen into disrepute. The new edition does not differ in principle from the older one, but new plates have been made so that the star images and names stand out with perfect clearness even by dim lantern light. The star places are referred to the equinox of 1925 and star magnitudes are taken from the Potsdam Durchmusterung and the Harvard southern zones. It also contains a key map of the Moon suitable for use with a three-inch telescope. I have used several other star charts but in my opinion this decidedly outclasses them all in genral usefulness. Its reasonable price, eighty-five cents, brings it within the reach of all students. Schurig's maps taken in connection with the constellation charts of POPULAR ASTRONOMY give all that the ordinary student needs to have.

Vassar College Observatory, CAROLINE E. FURNESS.
Poughkeepsie, N. Y.

THE GREAT FAINTNESS OF THE MARKINGS AND THE YELLOWNESS OF THE PLANET MARS. The most characteristic feature of the present apparition was, and still is to a large extent, the extreme faintness of the great majority of the dusky areas, which made *Mare Sirenum*, for instance, appear immensely darker than such markings as the *Syrtis Major* and *Sinus Sabaeus*. (See Fig. 1).

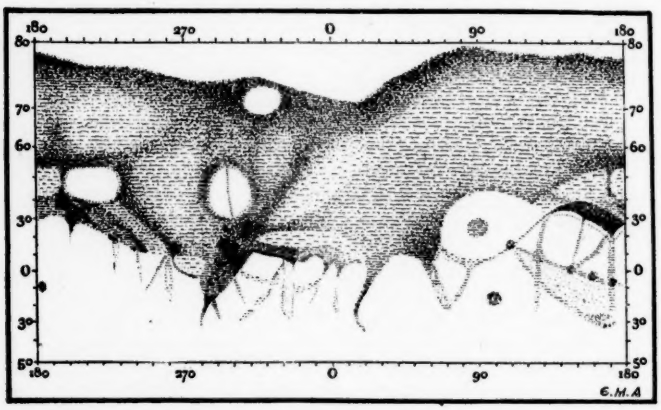


FIG. 1.—Chart of Mars on Mercator's projection, embodying all the observations made by the Director from 1909, August 14 to September 3, and showing the vast alterations in the intensity of the dusky areas.

Nothing similar had, of course, ever been seen during the past apparitions of the planet. What, however, struck the director, at the first glance thrown on Mars in August, was also the fact that the planet did not appear with its usual ruddy color, but was pale yellow; and this yellowness was immediately considered as intimately associated with, or an agent of, the faintness of the *Maria*. That this view was correct became evident between August 23 and 27. On those nights Mars presented to us the *Maria Sirenum* and *Cimmerium* regions, and the contrast between the normal ruddy ground in which the details were swarming N. of *Mare Sirenum* and the dull yellowness N. of *Mare Cimmerium*, where such dark spots as *Cyclops, Cerbeus,* and *Trivium Charontis* were virtually invisible (Figure 2), was too obvious to be missed by an observer who had closely studied Mars for ten successive apparitions.

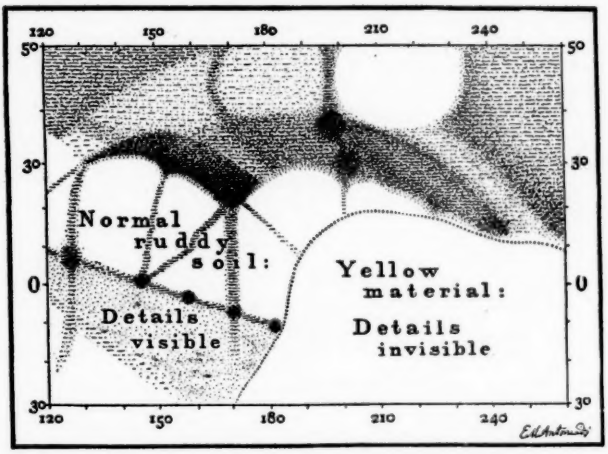


FIG. 2.—Appearance of the Martian country to the N. of *Maria Sirenum* and *Cimmerium* between 1909, August 23 and 27.

With regard to the nature of these abnormal appearances two theories force themselves upon us: either *(a)* that the *Maria* were discolored, or *(b)* that the markings were obliterated by cloud. Now, the former assumption is hampered by the necessity of supposing that at the same time when the dusky parts were being modified in tint (and seasonal change is rather unlikely in the tropical zone), a similar process of discoloration had also attacked the continental regions, which is scarcely likely. But the cloud theory is capable of explaining all the above facts in the simplest possible manner. However, by the word "cloud" the director would imagine only the lightest possible cirrus formation, or the thinnest conceivable haze, the diffusive effect of these condensations scarcely equalling the glare of our cloudless blue skies. Such a screen would render paler the dark spots, and it would appear of a light yellow—just as has been observed—over the continental regions, as transmitting and blurring the color of the ochre surface beyond, while the shadow it would cast on the planet would certainly interfere with its appearing too bright near the limb.

Journal of the British Astronomical Association, October 21, 1909. E. M. ANTONIADI.

In Starland with a Three-Inch Telescope. William Taylor Orcutt has written a book containing 146 pages with the title, "In Starland with a Three-Inch Telescope." It has forty diagrams of the constellations and eight of the Moon. It is conveniently arranged for the use of the amateur astronomer. It is just from the press of G. P. Putnam's Sons, New York and London.

The strong point in this new book is the convenience of its arrangement for study and observation. We have seen nothing better in this regard.

For illustration, if one turns to pages eight and nine, he will find there information pertaining to the constellations of Ursa Minor and Draco. On the left-hand page is a table of descriptive matter relating to the leading stars of these constellations, naming the double stars, magnitudes, distances, angles and remarks pointing out special features of interest in particular stars.

The right-hand page presents an outline or skeleton picture of these constellations with the prominent stars connected by lines and properly lettered as is usually done in good star catalogues. The author has ingeniously chosen a few symbols which serve his purpose of convenience of arrangement very well. As double stars are among the most interesting objects for the amateur, these are represented by outlined circles in the places of these stars respectively. The cross indicates the place of the nebula, and a group of dots signifies the position of a star cluster. With the descriptive matter on one page, and this illustrated matter on a page opposite to it, any one can see what a time saving arrangement this is. Forty-three constellations are grouped and presented in this way.

In a similar manner the Moon is presented, beginning with the narrow crescent, 3.85 days old, and ending with its age at 14.40 days, its eight phases are roughly pictured for identification and reference in study and observation. There is no attempt made to define these surface markings accurately; the drawings are for the purpose of recognition with the aid of the small telescope.

Attention is also given to occultations, brief study of the planets, and of the Sun, with indexes for the entire book. This book is a very useful one for the amateur.

Lowell Observatory Work in the German Museum. This museum at Munich, in which all fundamental discoveries and inventions in science are preserved has asked of Dr. Lowell, Director of the Lowell Observatory, for records of the observatory's work for their archives and permanent exhibition, comprising: a series of photographs of Mars, photographs of Jupiter, spectra of Mars—showing water vapor and comparison spectra, spectra of the other planets, the characteristic star spectra exhibited at Dresden last summer by Slipher.

In Germany it is considered one of the greatest honors to have one's discoveries entered in this museum of masterwork in science and technique ("Deutsches Museum von Meisterwerken der Naturwissenschaft und Teknik") and so far as known this is the first American observatory to be so honored.

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